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AFAL-TR-72-324

UHF COMMAND/SATELLITE TRANSCEIVER AN/ARC-151

J. Bruce Myers, Project Engineer

et al

Electronic Communications, Inc.
A Subsidiary of NCR

TECHNICAL REPORT AFAL-TR-72-324

(see form 1473)

DECEMBER 1972

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Air Force Avionics Laboratory
Air Force Systems Command
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FOREWORD

The work covered by this report has been accomplished by Electronic Communications, Inc., St. Petersburg, Florida, under Air Force Contract F-33615-69-C-1818, Project #687J.

This contract is under the technical direction of Mr. Lowell R. Nawman, AFAL/AAI, of the Air Force Avionics Laboratory, Wright-Patterson Air Force Base, Ohio.

Electronic Communications, Inc. activities on this project are under the direction of R. Saraydar, Project Manager and J. B. Myers, Project Engineer.

This report, which covers work performed from May 15, 1969 through September 6, 1972, was written by J. B. Myers with the assistance of the following: H. Z. Snyder and C. D. Donaldson.

Publication of this report does not constitute Air Force approval of the report's findings or conclusions. It is published only for the exchange and stimulation of ideas.

This report was submitted October 1972.

This report has been reviewed and is approved.

WILLIAM A. STUDABAKER
Lt Colonel, USAF
Chief, System Avionics Division
AF Avionics Laboratory

ABSTRACT

This report describes work on a UHF Command/Satellite Transceiver. The Radio Set is compatible and interchangeable with the AN/ARC-34( ). In addition, the Radio Set is compatible with the space requirements of the AN/ARC-27( ), AN/ARC-51( ), and AN/ARC-109( ). The set provides two-way AM voice, secure voice, FM voice, digital data, ADF, automatic relaying, FSK and satellite communications.

Two Radio Sets were built, tested, and delivered as part of this UHF Command/Satellite Transceiver Program. The two Radio Sets were originally shipped as identically configured AN/ARC-151(V) (XA-1) Radio Sets. Later, a modification to one of the originally shipped Radio Sets was requested which deleted the Link 4 Line-Of-Sight FSK Mode and incorporated a TTY 75 bps FSK Satellite Mode. Radio Set AN/ARC-151(V)(XA-1), serial number 00002, was modified, tested, renomenclatured Radio Set AN/ARC-151(V)(XA-2), and delivered as part of this program.

During the 75 bps FSK modification, the synthesizer was completely redesigned. Capabilities of the AN/ARC-151 have now been extended to meet:

- Extremely Low Phase Jitter Requirement
- Rapid Frequency Change
- Advanced Modulation Techniques
- Bi-Phase and Quadri-Phase PSK Modulation Requirements

Preliminary tests with external 70 MHz Modems using both Bi-Phase and Quadri-Phase PSK Modulation have been successfully carried out.

Radio Set AN/ARC-151(V) (XA-1) and the upgraded (XA-1) Radio Set AN/ARC-151(V) (XA-2) reflect the results of many years of detailed study and analysis into the latest state-of-the-art communications techniques. These Radio Sets provide an advanced baseline from which further state-of-the-art research may be continued or from which production may evolve. Whichever path is selected, that path can be pursued with confidence because of the successful conclusion of this AN/ARC-151 program.

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SECTION I

INTRODUCTION

The purpose of this contract is to extend the capabilities of the AN/ARC-145, ultra-reliable airborne UHF radio set, to include communications via a satellite as well as direct line-of-sight. Additional capabilities of the new radio set (UHF Command/Satellite Transceiver) shall include increased power output (100 watts FM, 25 watts AM), 25 kHz channel spacing, a narrow band (25 kHz bandwidth) FM capability, an external preamplifier (to be located at the antenna) and compatibility with an external voice modulator-demodulator for satellite use. Incorporation of the added features is such that production in large quantities will be possible with a minimum of engineering change. The UHF Command/Satellite Transceiver is compatible with the space requirements of the basic R/T for the AN/ARC-27( ), AN/ARC-34( ), AN/ARC-51( ), and AN/ARC-109( ). Also, the control unit of the UHF Command/Satellite Transceiver is mechanically interchangeable with that of the AN/ARC-34( ).

SECTION II

RADIO SET DESCRIPTION AND RATIONALE

1. GENERAL

Extension of Radio Set AN/ARC-145 to include satellite communications, higher power output, 25 kHz channel spacing, and compatibility with an external modem has been fully achieved during the development of Radio Set AN/ARC-151(V)(XA-1). Incorporation of these increased capabilities was accomplished with a minimum of changes to the existing AN/ARC-145. The modules basically common to the AN/ARC-151(V) (XA-1) and the 25 kHz version of the AN/ARC-145 are shown in the trapezoidal shaded area at the center of Figure 1. A block diagram of the AN/ARC-151(V) (XA-1) Radio Set is shown in Figure 2. New items and items with major changes are indicated by the shaded blocks. Each block in RT-1002 (R/T) represents an easily replaceable module.

Compatibility of the space requirements for the basic R/T of the AN/ARC-27, AN/ARC-34, AN/ARC-51, AN/ARC-109, and the AN/ARC-151(V) (XA-1) (ECI Model 977) is shown by reviewing Figure 3. Maximum dimensions of the AN/ARC-151 Receiver-Transmitter and mount do not exceed those of the other units shown. Actual physical replacement of the other Radio Sets was not accomplished during this program. However, an AN/ARC-151(V) (XA-1) adapter tray was built for the AN/ARC-34 position and delivered as part of this contract.

Satisfactory tests of the AN/ARC-151(V) (XA-1) in the FM Voice Mode were made through the LES-6 satellite. Communications were established through the ECI satellite laboratory using an ECI-built hand-held transceiver. Voice links were established using several types of antennae and Transmitter power levels. Communication was best when using the highest gain antenna and a 100 watt power level. However, usable communications were attained when using a blade antenna and a 70 watt Transmitter power output level.

Testing of the AN/ARC-151(V) (XA-1) Radio Set with various PSK and FSK 70 MHz modems has been conducted by the Air Force Avionics Laboratory (AFAL). Detailed results of these tests are included in the latest test report published by AFAL.[1] Early tests were successful with the AN/ARC-151(V) (XA-1) in the Receive Mode but not in the Transmit Mode. An interruption in the modem 70 MHz signal caused the AN/ARC-151(V) (XA-1) Transmitter protect circuits to disable the Transmitter. Consequently, modifications were made to the AN/ARC-151(V) (XA-1) to allow for 70 MHz modem signal interruptions. Later tests conducted by the AFAL proved successful for both transmit and receive of the AN/ARC-151(V) (XA-1) with 75 bps FSK data and 2400 bps PSK data from external modems.

Hardware modification of the AN/ARC-145 to produce the AN/ARC-151(V) (XA-1) are summarized in Table I. Changes listed in Table I were made to incorporate 25 kHz channel spacing and were not in the original statement of work. Also, during the time period when 25 kHz channel spacing was being considered, occupied bandwidth was reinserted as an important factor. Therefore, modifications to the AN/ARC-151 Radio Set were also made to fully comply with the occupied bandwidth requirement of MIL-STD-188. Authorization for these changes to both AN/ARC-151 Radio Sets was given in January of 1970 as amendment number 1 to the original contract. A similar but separate program for 25 kHz channel spacing and the MIL-STD-188 occupied bandwidth modifications was also made to one AN/ARC-145. For identification purposes the AN/ARC-145 with 25 kHz channel spacing will be referred to as the 25 kHz ARC-145.

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[1]Interim Test Report on Command/Satellite Transceivers ARC151/ARC152, AAI TM-72-2, 25 February 1972

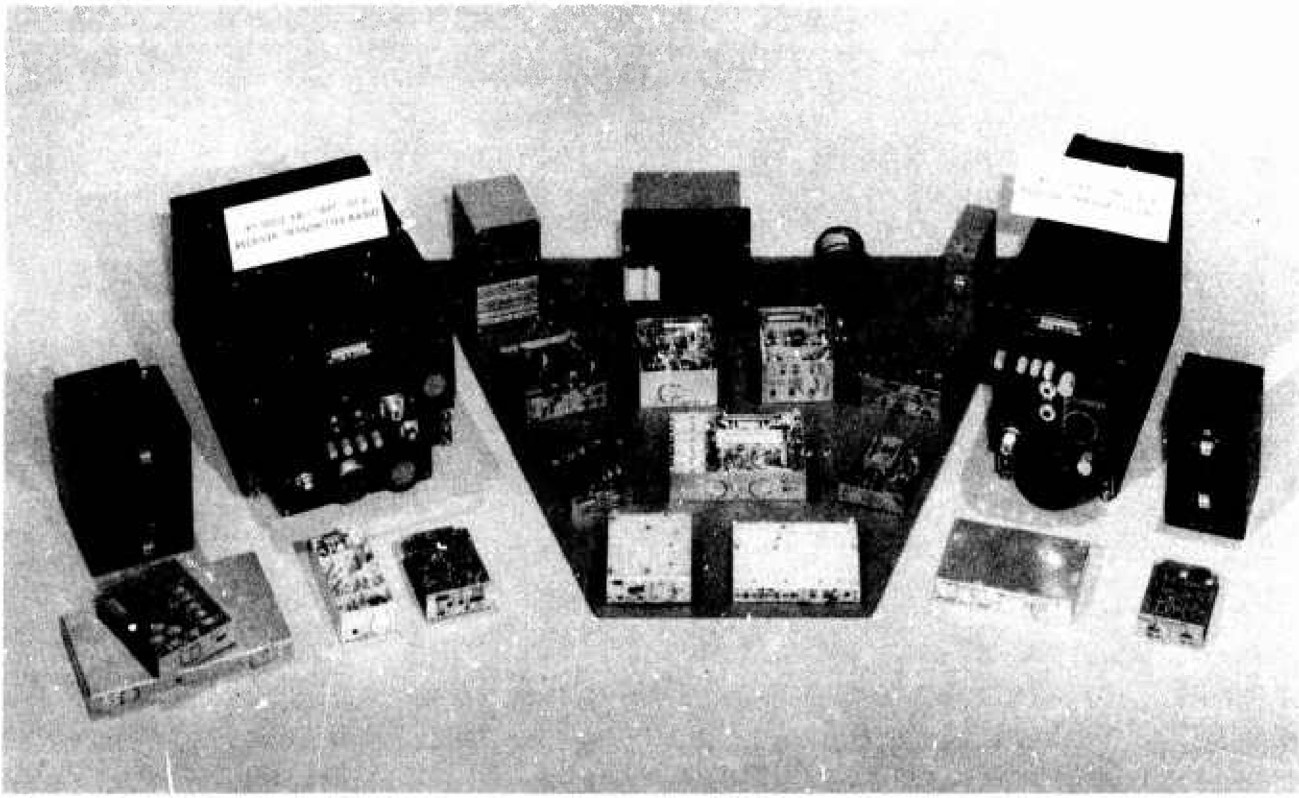


Figure 1. Comparison of Radio Sets AN/ARC-145 and AN/ARC-151(V) (XA-1)

Early in 1971, AN/ARC-151 contract amendment number 2 was awarded to ECI. This contract addition basically:

- Revised environmental and EMI testing requirements
- Added an AN/ARC-151(V) (XA-1) adapter tray for the AN/ARC-34 position
- Added the 75 bps Modulator and Demodulator requirements for Radio Set serial number 00002

Radio Set AN/ARC-151(V) (XA-1) serial number 00002 was then modified and the nomenclature changed to AN/ARC-151(V) (XA-2). A description of the modification is given in Section III of this report.

2. R/T CHASSIS AND PACKAGING

Relative R/T module placement and overall chassis dimensions are shown in Figure 4. As in the AN/ARC-145, the Power Amplifier and Power Supply modules dissipate the largest amount of power, and therefore, are placed by the heat exchanger. The power dissipated by the Synthesizer, Data Converter, Exciter, and T/R Switch required these modules to be located adjacent to the outside of the chassis.

Numerous isolation schemes were investigated with the intent to leave space for the largest heat exchanger, Power Amplifier, and Power Supply possible. The best arrangement found used the same isolator as those used on the AN/ARC-51 and AN/ARC-109 Radio Sets. These are the HTO series isolator made by the Lord Manufacturing Company.

Early estimates confirmed by a detailed computerized thermal analysis indicated the AN/ARC-145 blower was the best choice for the AN/ARC-151. Preliminary temperature-altitude testing followed by formal environmental testing yielded Radio Set temperatures slightly lower than those previously predicted when using the AN/ARC-145 blower.

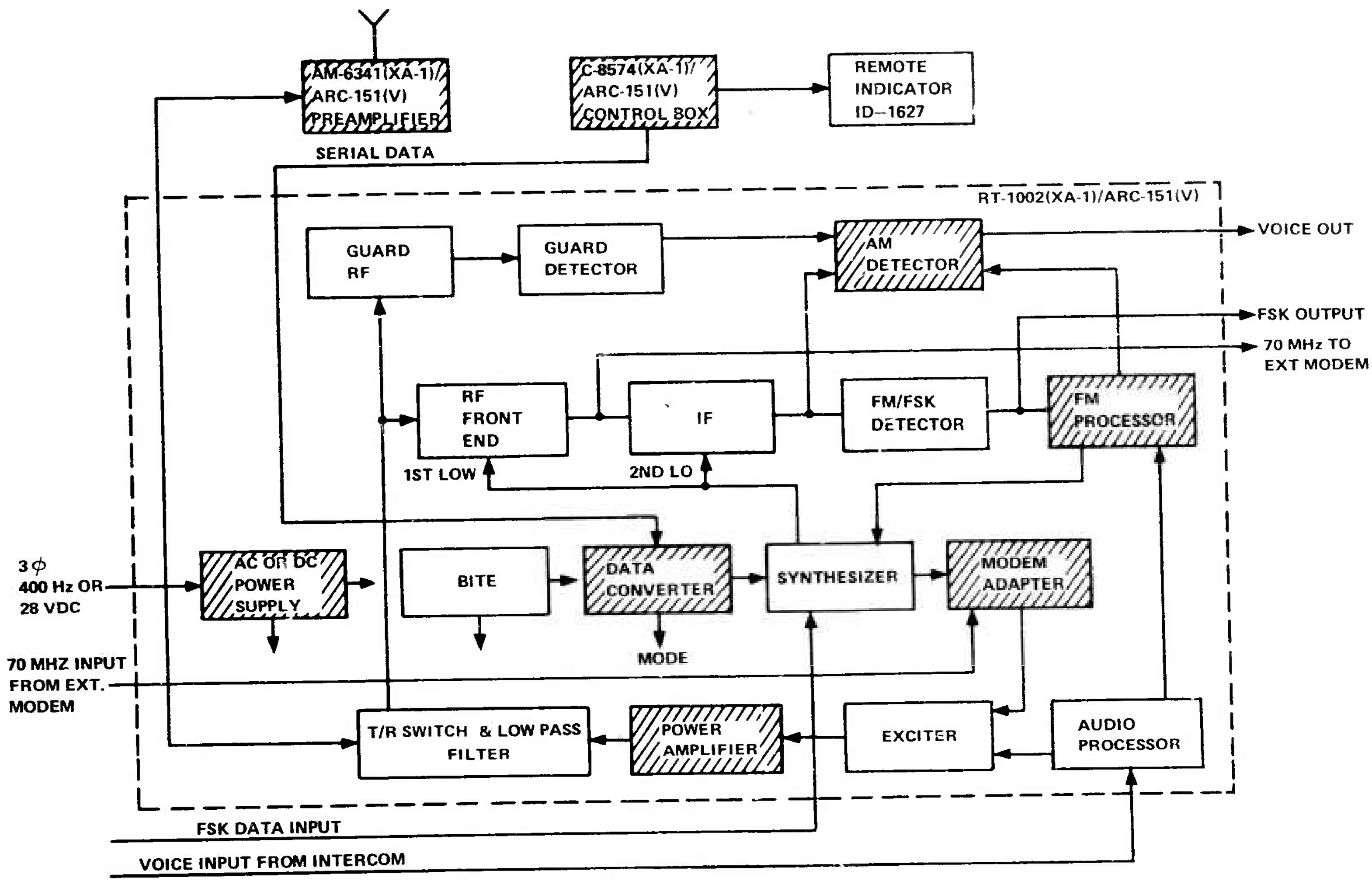


Figure 2. Radio Set AN/ARC-151(V) (XA-1) Block Diagram

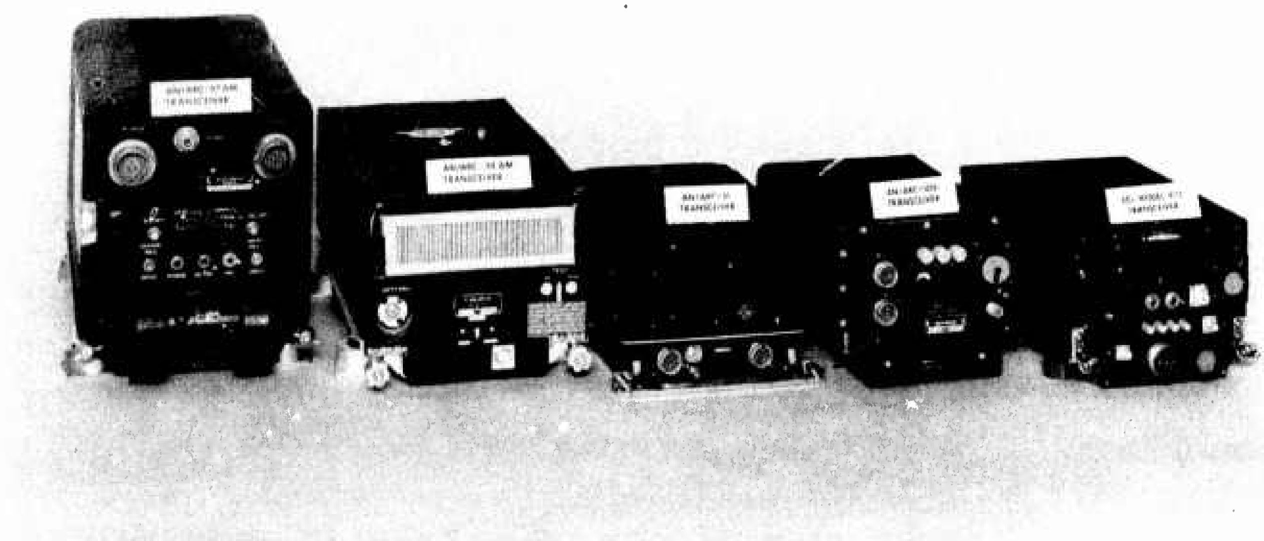


Figure 3. ECI Model 977 Transceiver Compared With Radios To Be Replaced

Table I. AN/ARC-151(V) (XA-1) Design Areas and Comparison To AN/ARC-145

Component	Description Of Design Change and Comparison To AN/ARC-145
Chassis	a. Same construction techniques as used on AN/ARC-145
	b. Complete relay out required to allow for three modules made larger and two new modules
Main R_X RF Amp and Mixer	Identical to module used in AN/ARC-145
Power Amplifier	a. Redesigned to give 100 watts output
	b. IPA submodule identical to AN/ARC-145
	c. Dual submodule designed for AN/ARC-151 but also now used on AN/ARC-145
	d. Chassis layout and other submodules unique to AN/ARC-151
Exciter	a. Loop bandwidth extended and gain increased on power level control circuit to allow tighter power level control
	b. Overpower protect and temperature crank back circuits added
	c. Automatic recycling added to protect circuits and other minor circuit modifications made to allow operation with external 70 MHz Modems

Table I. AN/ARC-151(V) (XA-1) Design Areas and Comparison To AN/ARC-145 (Continued)

Component	Description Of Design Change and Comparison To AN/ARC-145
T/R Switch	a. Heat sink added to Transmitter PIN diode b. Heat sinks added to Transmitter low pass filter c. Directional coupler redesigned to give flatter response and reduced assembly costs
BITE	a. Single frequency check deleted b. Noise figure test reduced from checking five channels to checking channel in use only c. Transmitter BITE sequence changed to operate without a directional coupler in P. A. module d. All modifications accomplished with only minor PCB assembly revisions
FM/FSK Detector	Identical to module used in AN/ARC-145
IF Amplifier	Identical to AN/ARC-145 IF except for a narrower, steeper skirted narrow band crystal filter incorporated for 25 kHz channel spacing
AC & DC Power Supplies	a. Increased output of 28V regulators to 18 amps b. Added overload protection c. Extensive repackaging to accommodate additional circuitry and larger heatsink d. Used AN/ARC-145 receiver converter without circuitry change and with only minor mounting changes
Guard RF	Identical to AN/ARC-145 module
Guard Detector	Identical to AN/ARC-145 module
AM Detector	a. Modified squelch circuitry to be compatible with new IF narrow band filter b. Replaced noise limiter with noise blanker to improve impulse noise rejection c. New PC board layout d. Identical to module used in 25 kHz AN/ARC-145
Data Converter	a. Added satellite offset programming b. Modified logic outputs to be compatible with new modes and modules c. Added 25 kHz channel spacing

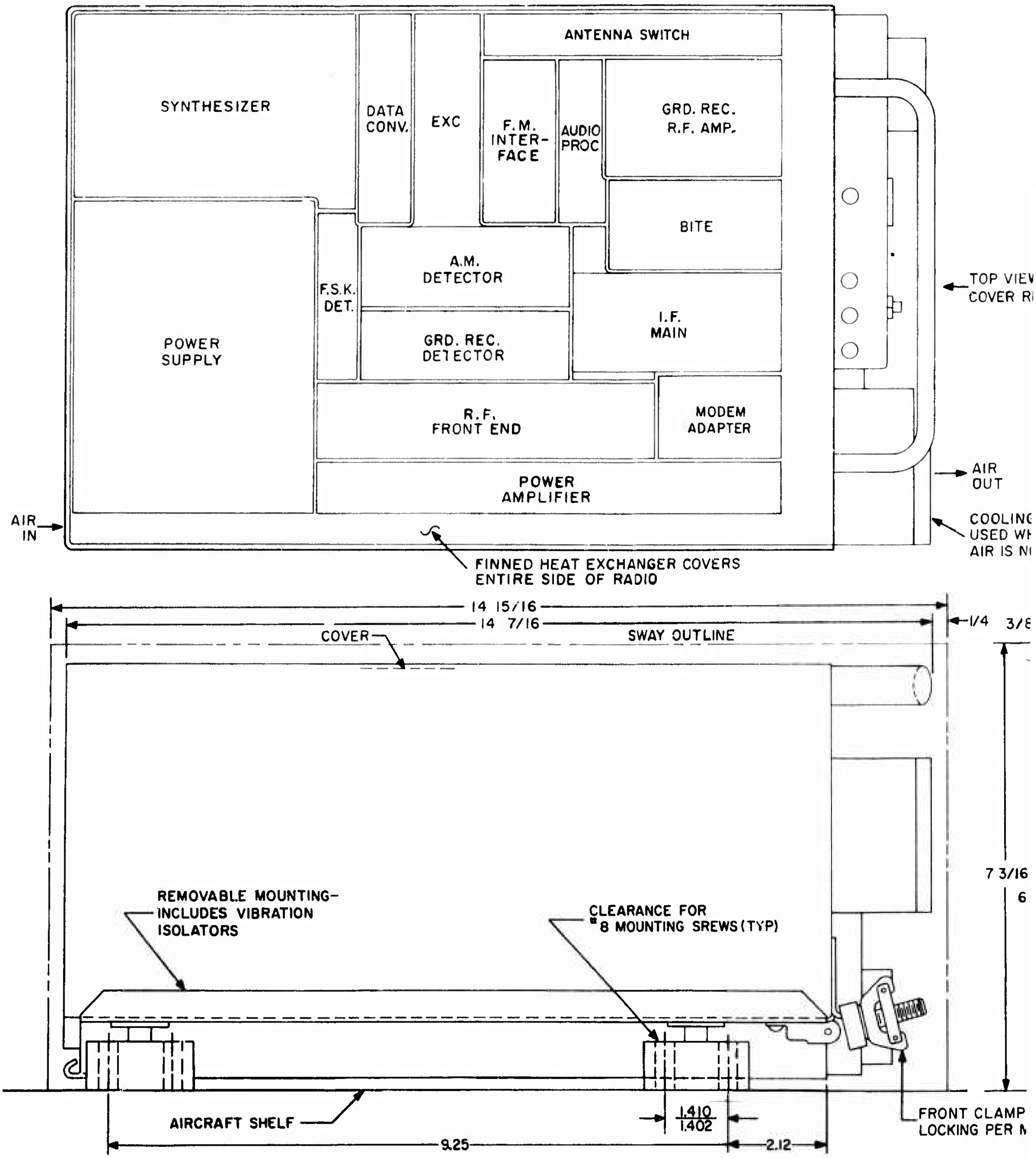
Table I. AN/ARC-151(V) (XA-1) Design Areas and Comparison To AN/ARC-145 (Concluded)

Component	Description Of Design Change and Comparison To AN/ARC-145
Data Converter (Cont)	d. Shift register PC board similar to AN/ARC-145 in design
	e. Completely repackaged
Audio Processor	a. Changed low pass filter from RC filter to elliptical function filter
	b. New PC board layout
	c. Identical to 25 kHz AN/ARC-145
FM Processor	New module
Modem Adapter	New module
Synthesizer	a. Modified programmed divider PC boards to include 25 kHz pulse groups
	b. Changed frequency code from Wagner to BCD
	c. Changed ceramic boards to glass-epozy boards
	d. Three new PC board layouts
	e. Identical to 25 kHz AN/ARC-145
Control Box	a. Added 25 kHz control to front panel
	b. Added 25 kHz control to circuitry
	c. Changed frequency code from Wagner to BCD
	d. Changed frequency display from electronic to mechanical
	e. Added two additional bits to memory
	f. Extensive mechanical repackaging
	g. Very similar to 25 kHz AN/ARC-145
Remote Indicator	a. Added 25 kHz display to readout
	b. Identical to 25 kHz AN/ARC-145
Preamplifier Assembly	New assembly

A detailed weight study of the R/T Unit predicted the total weight of the R/T Unit (less blower and mount) would be slightly less than the maximum allowable 30 pounds. During the program, weight control was maintained on a continuing basis. In all cases trade-offs were made in module construction with respect to weight, cost, and ease of manufacture. Table II provides a breakdown of the R/T Unit actual weights. Total weight of the R/T Unit is less than 30 pounds. As shown in the table, actual weight of the Radio Set (less blower) is 29.79 pounds. The blower and guard weigh 0.66 pounds.

Table II. Radio Set Weights Breakdown

Item	Weight (#)
R/T Case and Heat Exchanger (less Blower)	9.52
Power Supply	8.86
Synthesizer	2.55
Power Amplifier	2.09
Audio Processor	.20
RF Front End	1.38
Exciter	.65
TR Switch	.45
Guard Receiver RF Amplifier	.77
Data Converter	.34
FM Detector (FSK)	.18
Guard Receiver Detector	.43
AM Detector	.36
Main IF	.80
BITE	.39
FM Processor	.24
External Modem Adapter	.58
Total (less blower)	29.79
Blower and Guard	.66


ANTENNA SWITCH
SYNTHESIZER
DATA CONV.
EXC
F.M. INTER-FACE
AUDIO PROC
GRD. REC. R.F. AMP.
BITE
A.M. DETECTOR
F.S.K. DET.
GRD. REC. DETECTOR
I.F. MAIN
POWER SUPPLY
R.F. FRONT END
MODEM ADAPTER
POWER AMPLIFIER
AIR IN
AIR OUT
TOP VIEW COVER R
COOLING USED WH AIR IS N
FINNED HEAT EXCHANGER COVERS ENTIRE SIDE OF RADIO
14 15/16
14 7/16
1/4
3/8
COVER
SWAY OUTLINE
7 3/16
6
REMOVABLE MOUNTING-INCLUDES VIBRATION ISOLATORS
CLEARANCE FOR #8 MOUNTING SREWS (TYP)
AIRCRAFT SHELF
1.410
1.402
9.25
2.12
FRONT CLAMP LOCKING PER M

Figu

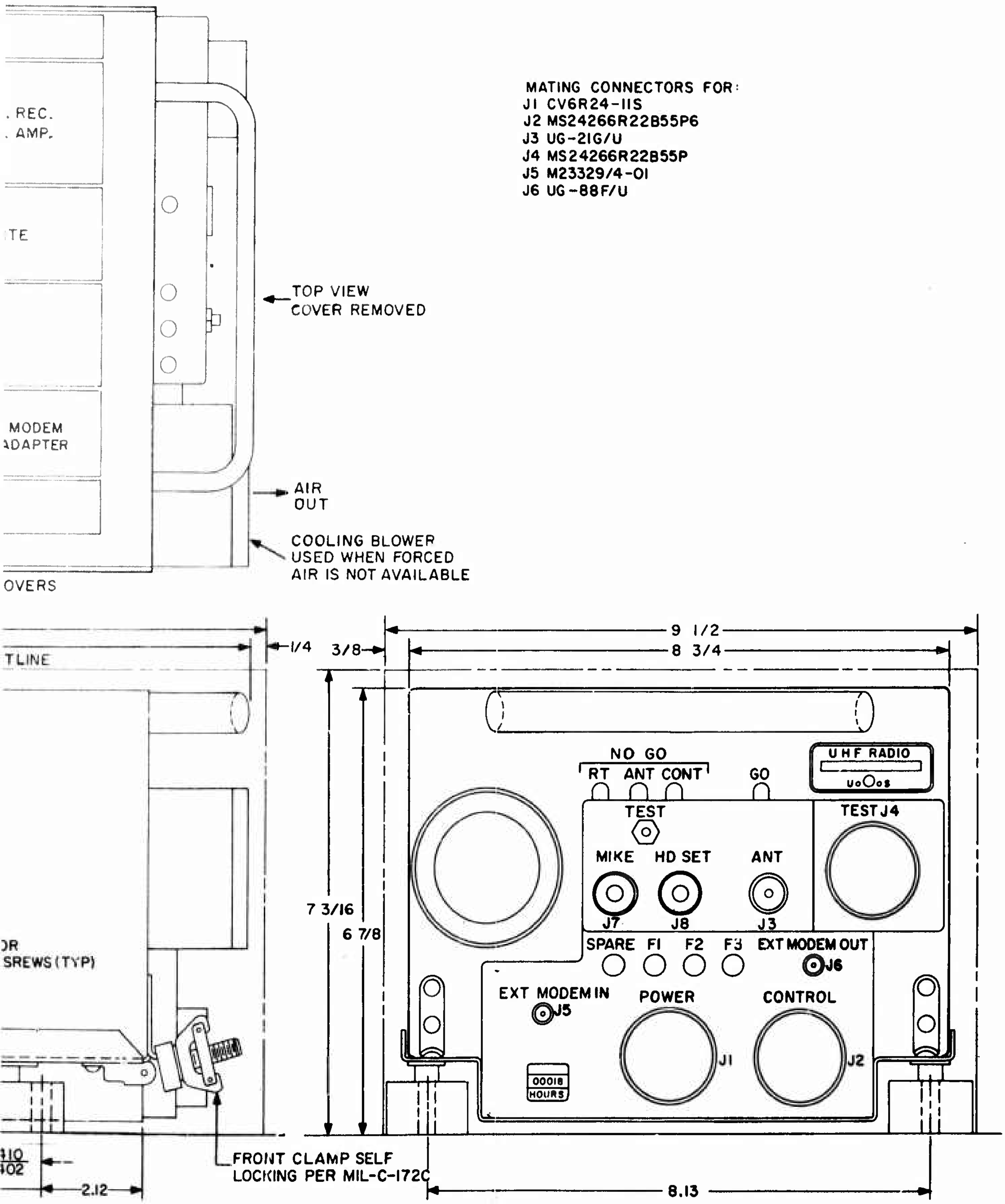


Figure 4. UHF Command/Satellite Transceiver Layout

3. POWER AMPLIFIER

The Power Amplifier (P. A.) as shown in the block diagram in Figure 5 functions as a final frequency Power Amplifier which increases the power level from the Exciter to 25 watts in the AM mode and 100 watts in the FM mode. Components of the P. A. consist of an IPA, four identical dual transistor submodules, a three-way coaxial splitter, a three-way coaxial combiner, and a protect unit. Figure 6 illustrates an actual P. A. with the cover removed. From left to right the submodules are the three-way coaxial combiner, three duals, a three-way coaxial splitter, another dual at the top, the protect unit at the bottom, and at the extreme right the IPA. All of these submodules are bolted to an 0.2 inch thick aluminum plate which is in turn bolted to the Radio Set heat exchanger. Each submodule has a 50 ohm input/output interface and is completely tested before being assembled into a P. A.

The IPA submodule consists of two transistors in series giving a power gain of 10 dB minimum. This submodule is used directly from the AN/ARC-145. Power output capability of the IPA is 20 watts. Normal output level of the IPA used in the AN/ARC-151 P. A. is 10 watts.

A block diagram of the dual submodule is shown in Figure 7. The input consists of a two-way 90° hybrid power splitter which feeds two transistors. The transistor outputs are combined in another identical two-way 90° hybrid combiner. Isolation between the transistors is excellent because the hybrid splitter and combiner dump input and output unbalances into 50 ohm terminating resistors. Each dual submodule is tested to an output of 50 CW watts across the 225 to 400 MHz band.

Basic construction of the three-way splitter and the three-way combiner is the same. Each consists of three precise lengths of 70 ohm coaxial cable connected together at one end. When the proper length of coaxial cable is used, a passive device results which provides a 50 ohm interface and will split or combine power. Insertion loss is a fraction of a dB and only results from the coaxial cable losses.

A unique protection feature is incorporated into the hybrid circuits. Voltage appearing across the dump terminating resistors of the three output duals is continuously sensed. If any one of the six output transistors fails, the signal unbalance is sensed at the dump port on the output side of the dual. The RF is then detected and the resultant DC signal inhibits the P. A. module drive minimizing any further damage. An additional feature is a temperature protection circuit which automatically reduces the FM power output if the base plate of the P. A. becomes excessively hot, keeping the junction temperature of the RF power transistors within their ratings under adverse conditions.

VSWR protection circuitry for the P. A. is incorporated into the Exciter and T/R Switch modules. The T/R Switch has forward and reverse power couplers which are used to send forward and reverse power information to the Exciter. The forward and reverse power data is compared in the Exciter and used to reduce the Transmitter power output when a mismatch condition occurs. Power output is gradually reduced to a maximum reduction of 1 dB at a VSWR of 2.5:1. The Transmitter is turned off for a VSWR of 3:1 and above. If the power output of the Transmitter exceeds 120 watts, the forward power coupler output senses an overpower condition and turns the Transmitter off.

4. EXCITER

The Exciter module controls the operation of the Transmitter as well as amplifying an RF signal from zero dBm to one watt. The Exciter as shown in the block diagram (Figure 8) performs the following Transmitter control functions:

- Low Level AM Modulation
- Transmitter power output "ON" and "OFF"
- Transmitter power level control
- P. A. VSWR Protection
- P. A. Temperature Protection

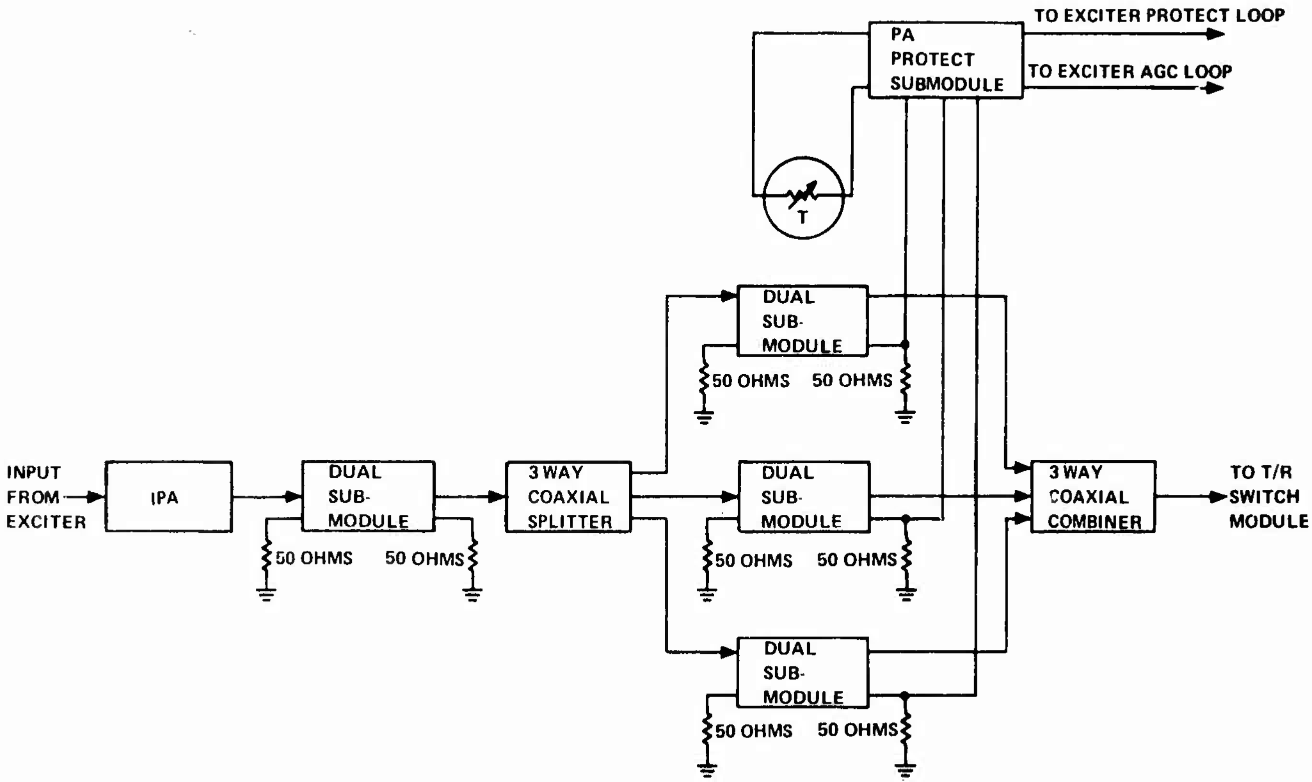


Figure 5. Power Amplifier Block Diagram

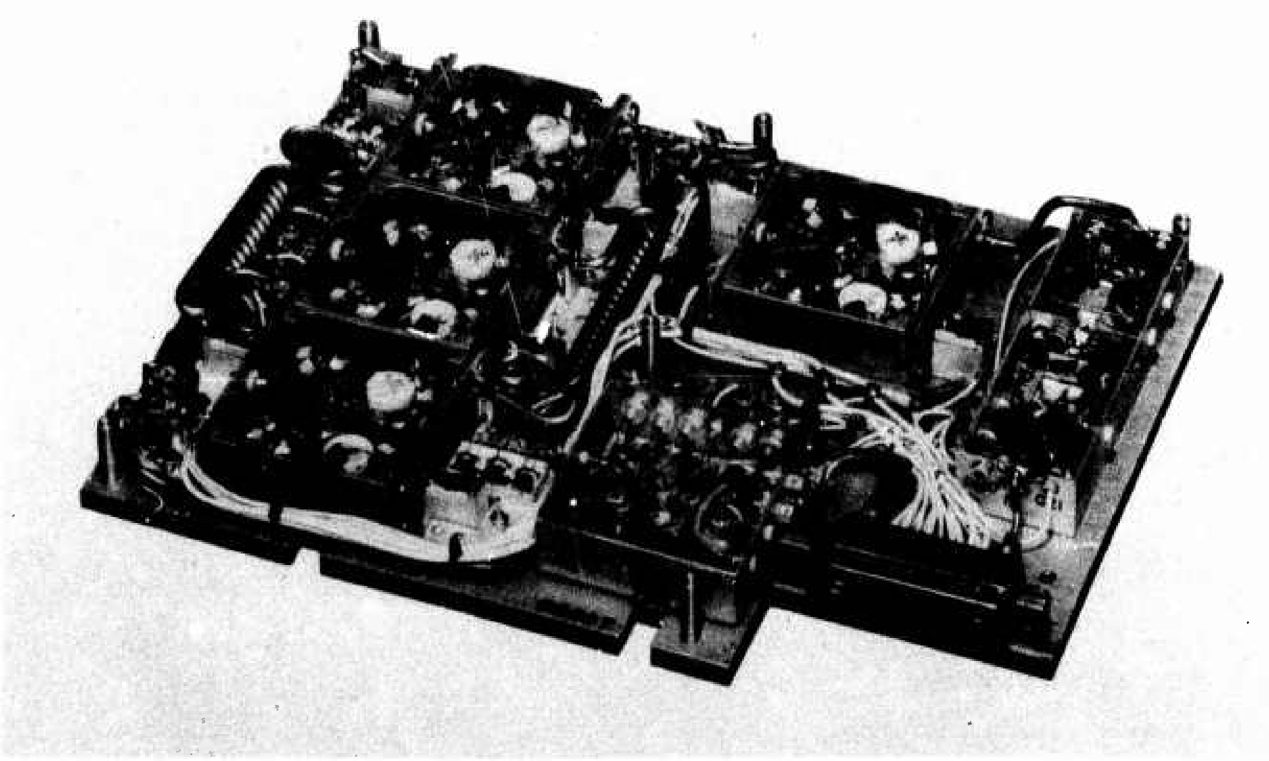


Figure 6. Power Amplifier With Cover Removed

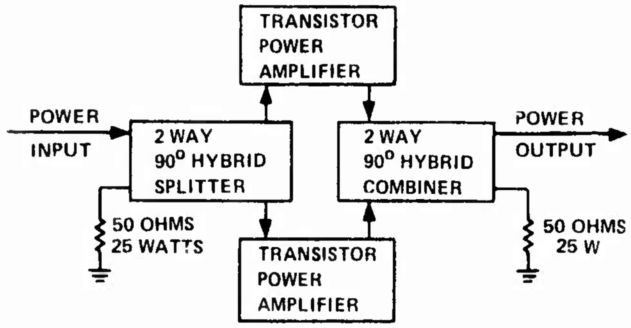


Figure 7. Power Amplifier Dual Submodule Block Diagram

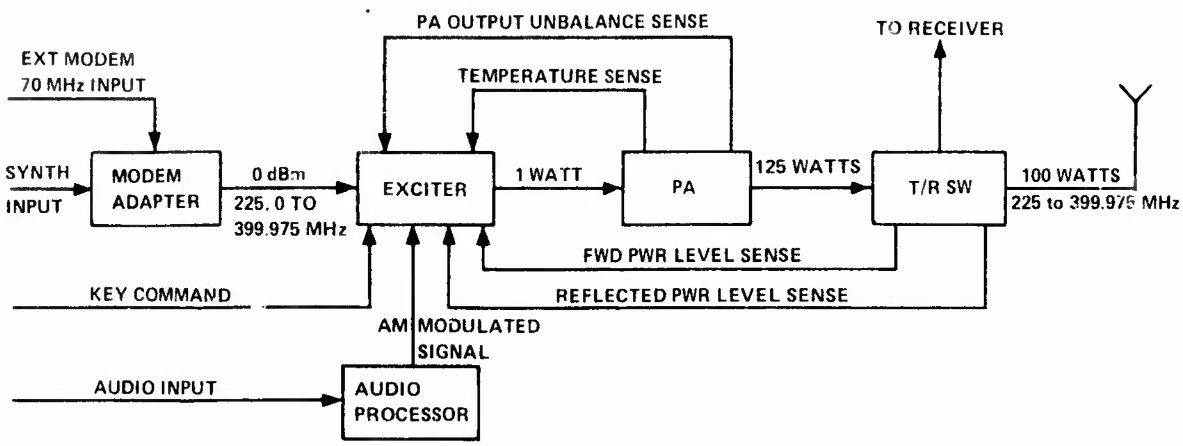


Figure 8. Transmitter Block Diagram

- P. A. Over Power Protection
- P. A. Output Amplifier Unbalance Protection

Two features added to the AN/ARC-145 Exciter for the AN/ARC-151 application are P. A. Temperature Protection and Unbalance Protection. Operation of these new functions is described in the P. A. Section. Another improvement flattened the output power level across the 225.0 to 399.975 MHz band. By improving the power level control, the overpower protection circuit was set closer to the operating power output of the Transmitter.

During testing of external modems with the Radio Set, carrier zeroes in the external modem 70 MHz signal caused the Exciter P. A. protect circuits to activate. Protect circuit activation resulted in the Transmitter power output being latched off. Power output could only be restored by manually reinitiating the Exciter key command. As a result of this experience, the Exciter was modified to automatically recycle the Exciter key approximately 20 useconds after a protect circuit initiated power shutdown.

Modifications to incorporate new circuits in the Exciter were accomplished by redesigning one of the two existing Exciter PC boards. A slightly different test point arrangement at the top of the Exciter module was also necessitated by this redesign.

5. T/R SWITCH

A block diagram of the T/R Switch is shown in Figure 9. As well as performing the T/R switching function, the T/R Switch module provides filtering of the Transmitter power output and houses a directional coupler used for Transmitter power output control. Modifications were made to the AN/ARC-145 module to increase the power capability of the diode switch and the low pass filter. A new directional coupler design was incorporated to reduce assembly costs and improve design margins. During the early program phases, only the diode switch improvement was planned. However, results from module testing indicated that low pass filter upgrading was also required. An ECI sponsored stripline research program provided the techniques to easily incorporate a new directional coupler which flattened the Transmitter power output level vs frequency curve.

The Transmitter power output path through the diode switch is shown in Figure 10 by the heavy line. Only one diode, CR1, and three capacitors are in series with the Transmitter output in the T/R Switch. The increased dissipation in CR1 for the higher power levels of the AN/ARC-151 required the addition of a heat sink to the existing PIN diode used. Figure 11 illustrates the new heat sink mounted PIN diode installed in the T/R Switch module.

During integration of the Transmitter modules into the first Radio Set chassis, an overheating problem was found in the T/R Switch low pass filter. Under a 100-watt output condition at the high end of the band (375 to 400 MHz), it was found that heating in the low pass filter element caused the detuning of the filter pass band characteristics. As the filter detuned, additional heating was enduced and a thermal runaway condition developed. The problem was resolved by adding eight small alumina blocks, as shown in Figure 11, between the filter element and the module case. These blocks substantially reduced the operating temperature of the filter element and prevented thermal runaway. The blocks did increase the filter insertion loss from 0.9 dB to 1.15 dB. However, the additional loss has proven to be a reasonable and a necessary tradeoff.

A special type of teflon and glass printed circuit board was used for the new directional coupler. Normal printed circuit board material, G11, could not be used because of the high power levels. Since the existing diode switch was physically located in the same area as the coupler, the switch was also incorporated onto the coupler printed circuit board. The resultant coupler/switch configuration is shown in the lower left-hand section of the T/R Switch module. Worst case insertion loss of the coupler/switch is 0.5 dB.

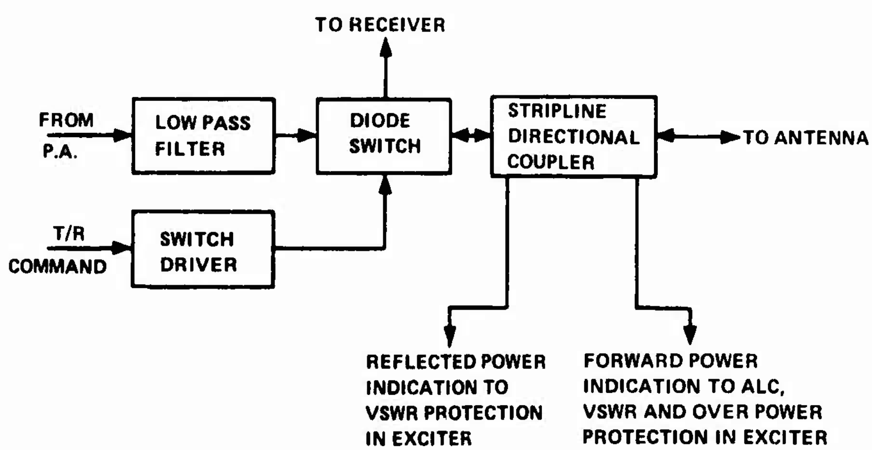


Figure 9. T/R Switch Module Block Diagram

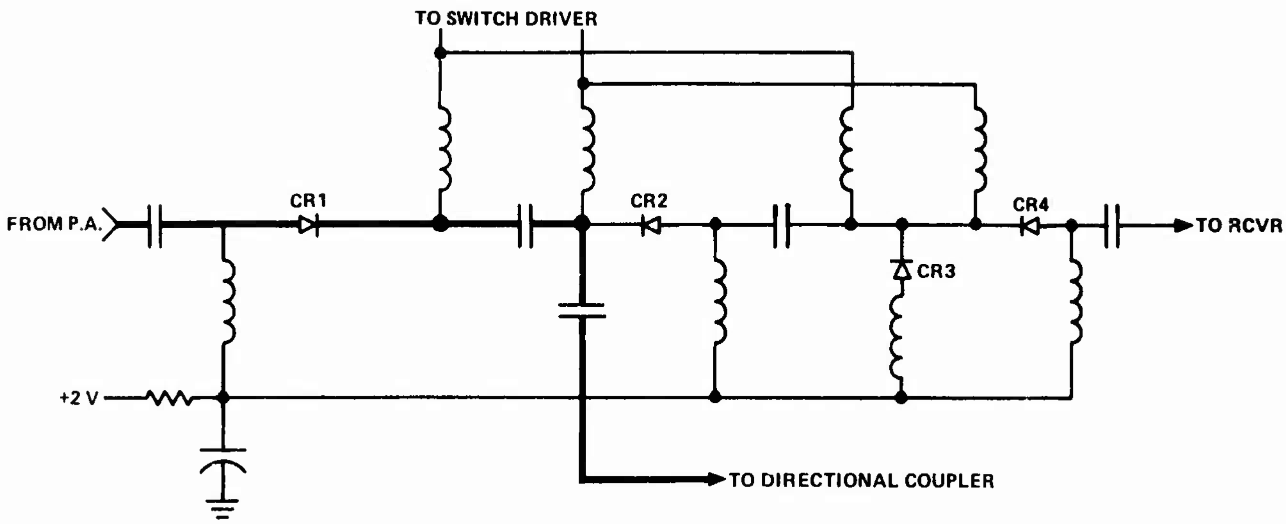


Figure 10. T/R Switch - Diode Switch Schematic Diagram

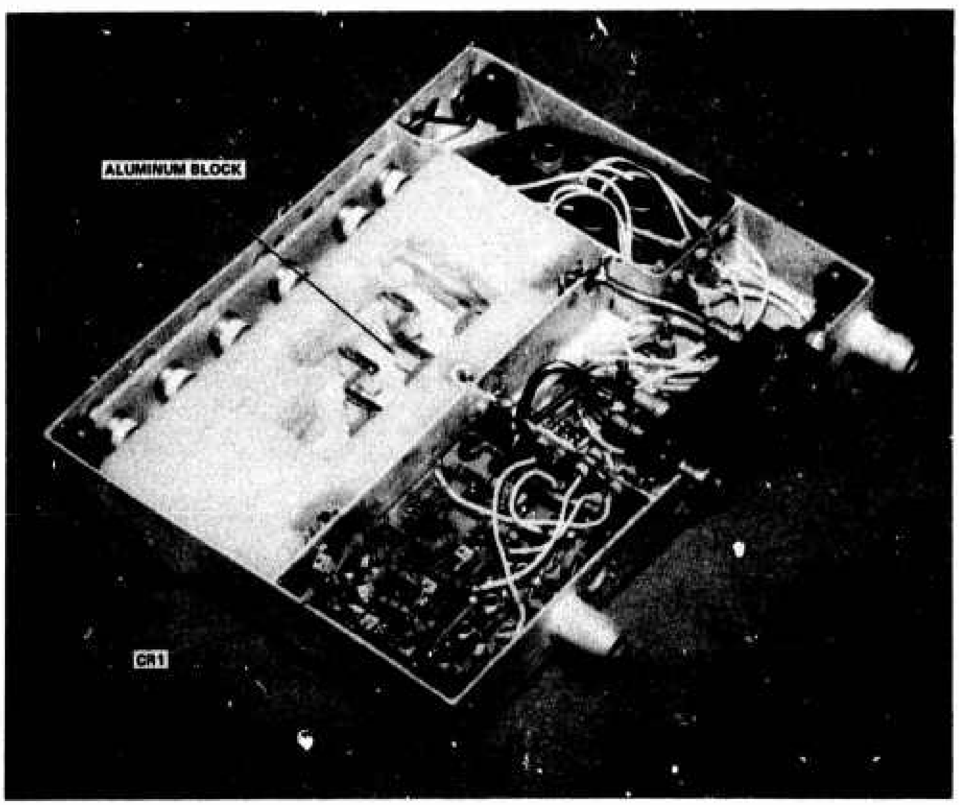


Figure 11. T/R Switch Module With Cover Removed

6. BITE

The function of the BITE module is to self test the Radio Set, Control Unit, and Antenna VSWR. Results of the self test are then displayed as a "GO" or a "NO GO" on the front panel for each respective "RT," "ANT," or "CONT." To simplify the BITE module functions and to allow the AN/ARC-145 BITE to work effectively with the AN/ARC-151(V) (XA-1), a few minor modifications had to be made to the ARC-145 BITE module.

Table III lists the operation of the BITE module functions in tabular form. Deleted AN/ARC-145 functions are crossed out with a line. New functions are noted with the addition of (New for AN/ARC-151).

Table III. BITE Module Functions

Measurement Functions	BITE 1	Step 2	Sequence 3
Measure Main Receiver N. F.		X	
Measure Main Audio Output		X	
Measure Main Squelch Circuit	X		
Measure FSK Detector Output		X	
Measure Guard Receiver N. F.		X	
Measure Guard Audio Output		X	
Measure Guard Squelch Circuit	X		
Measure Transmitter Output			X
Measure Antenna Reflected Power			X
Measure Transmitter Modulation (Sidetone)			X
Measure Synthesizer Out-of-Lock	X	X	X
~~Measure Synthesizer (Single Freq. Check)~~	~~X~~		
Measure Data Converter	X	X	X
Measure Control Box	X		

Control Functions

Control Functions	BITE 1	Step 2	Sequence 3
Receive BITE Command and turn on BITE lights	X		
Turn off Proper lights and send BITE result			X
~~Tell Synthesizer to ignore Control Unit (5 channel check)~~	~~X~~	~~X~~	~~X~~
Put Synthesizer in transmit	X		X
Put Exciter and T/R Switch in transmit	X	X	X
Put FM processor in transmit mode (New for AN/ARC-151)		X	X
Put Preamp in transmit mode (New for AN/ARC-151)	X	X	X
Key Transmitter			X
Turn on chassis noise generator		X	
Turn on tone generator			X
Disable main receiver squelch		X	
Disable guard receiver squelch		X	
Turn guard receiver on	X	X	
Enable main receiver squelch	X		
Enable gua d receiver squelch	X		

7. IF AMPLIFIER

Modification to the IF Amplifier for 25 kHz compatibility was accomplished by replacing the existing narrowband crystal filter with an even narrower-steeper skirted filter. Specifications for the new and old filters are as follows:

Characteristic	New Filter	Old Filter
f_0	8.8 MHz	8.8 MHz
I_L	5 dB maximum	5 dB maximum
Ripple	1.5 dB	1.5 dB
$BW_{1.5\ dB}$	30 kHz minimum	32.4 kHz minimum
$BW_{6\ dB}$	---	40 kHz maximum
$BW_{60\ dB}$	36 kHz maximum	90 kHz maximum
R_{in} & R_{out}	50 ohms	50 ohms
Temperature Response	-55 C to +110 C	-55 C to +110 C
Spurious Response	70 dB atten. minimum	70 dB atten. minimum
Maximum size	2.39" x 1.077" x 0.635"	2.41" x 1.015" x 0.635"

Since the new filter skirts were to be extremely steep (shape factor 1.2:1), at least two independent sources for the filter were felt necessary. After a vendor survey TMC Systems, Inc., Bulova Watch Company, and CTS Knight were given orders.

TMC Systems, Inc. designed the filter on paper and were optimistic toward building a prototype. However, TMC encountered processing difficulties that could not be resolved within the scheduled limits.

Bulova Watch Company delivered a working filter which was very close to the specification requirements but was 36.9 kHz wide at the 60 dB point and had three spurious responses less than 70 dB down.

CTS Knight was having space and spurious problems but still felt the filter could be built within the specification limits. Unfortunately CTS Knight did not deliver a filter in time for equipment use, but did deliver a filter almost within specification limits before the program closed.

Bulova Watch Company felt confident they could resolve all problem areas and therefore a second filter was purchased from them. Figure 12 shows the narrowband response of the IF Amplifier using the second filter from Bulova. All other filter parameters were also within their specification units. Figure 13 shows the first filter from Bulova installed in the IF Amplifier. Although the size of the Bulova filter was slightly different than the original narrowband filter, the IF Amplifier mounting area was large enough to accommodate the new design.

Testing the performance of the new filter in the Radio Set was somewhat of a problem. Since the slopes of the filter have at least 5 dB response change per 500 Hz frequency change, measuring the selectivity characteristics required precision measurement techniques. Figure 12 represents data taken with the IF in the radio just prior to shipment. All other radio parameters affected by IF Amplifier performance were within specification requirements.

8. AC AND DC POWER SUPPLIES

Operation of the Radio Set may be accomplished from either a 28 VDC Power Supply or a 3 phase 400 Hz Aircraft Power Supply. This is possible by having two separate but interchangeable AC and DC Power Supplies as shown in Figures 14 and 15. Design of the two power supplies is basically the same as that for the AN/ARC-145. The 28 VDC regulator sections of both supplies (see figures 16 and 17) were reworked extensively to supply the higher power requirements of the AN/ARC-151. For the Receiver Converter section, the AN/ARC-145 circuitry was used without change except for packaging. Overload protection was added to both the AC and DC supplies where space was available.

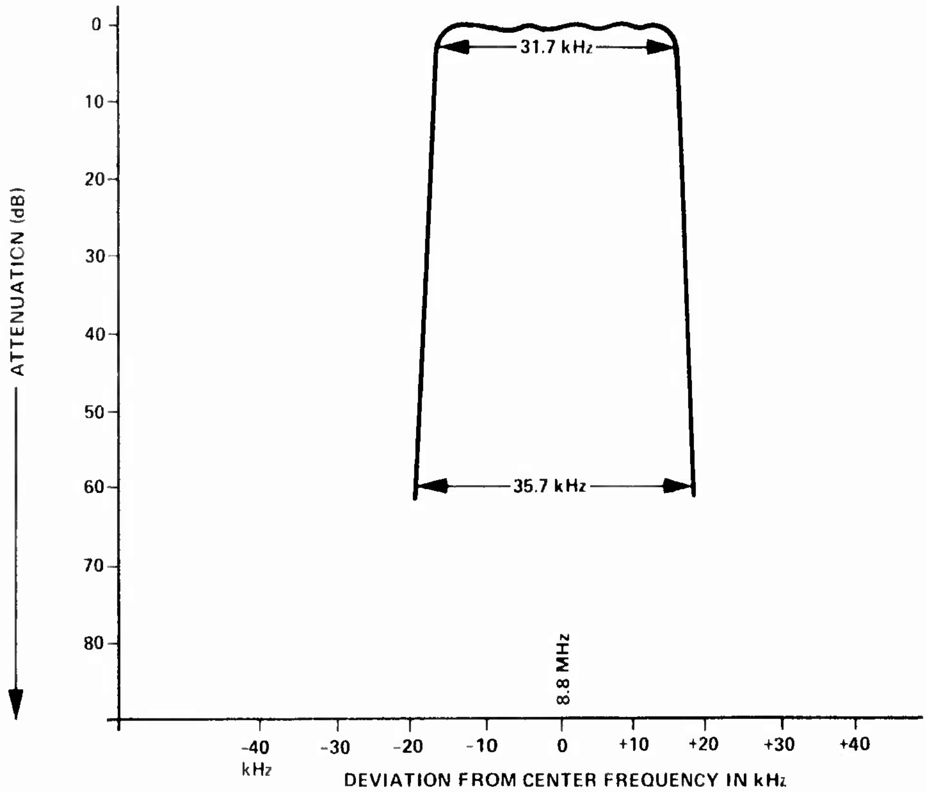


Figure 12. IF Amplifier Narrowband Response

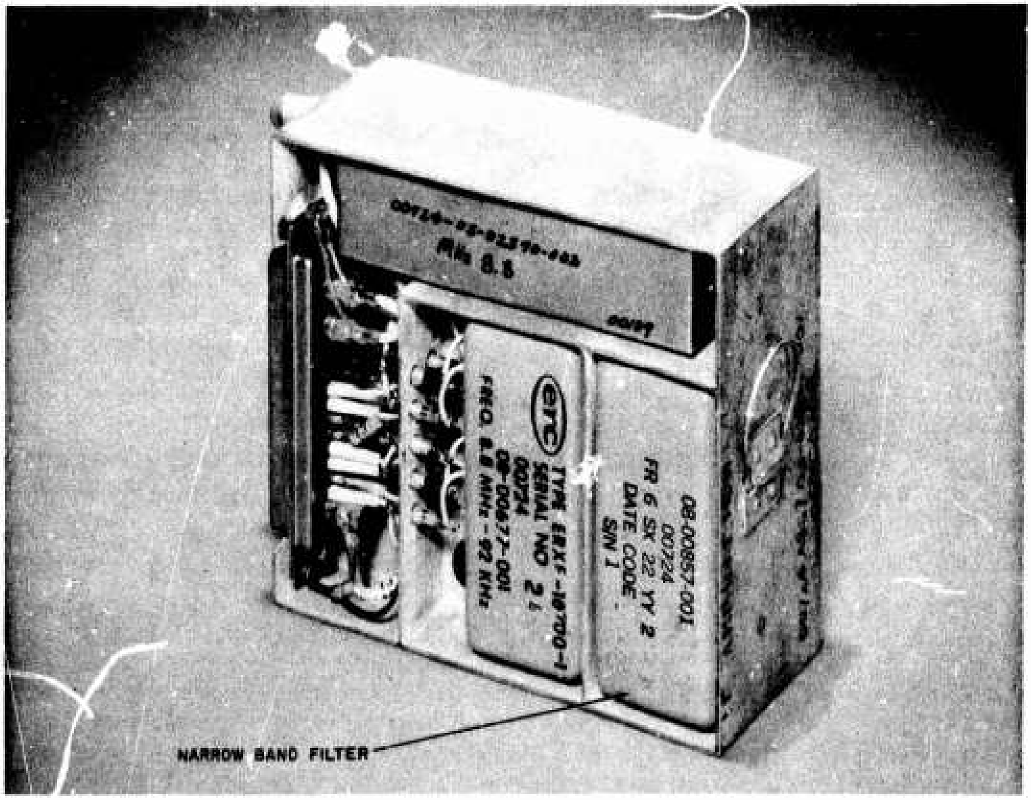


Figure 13. IF Amplifier

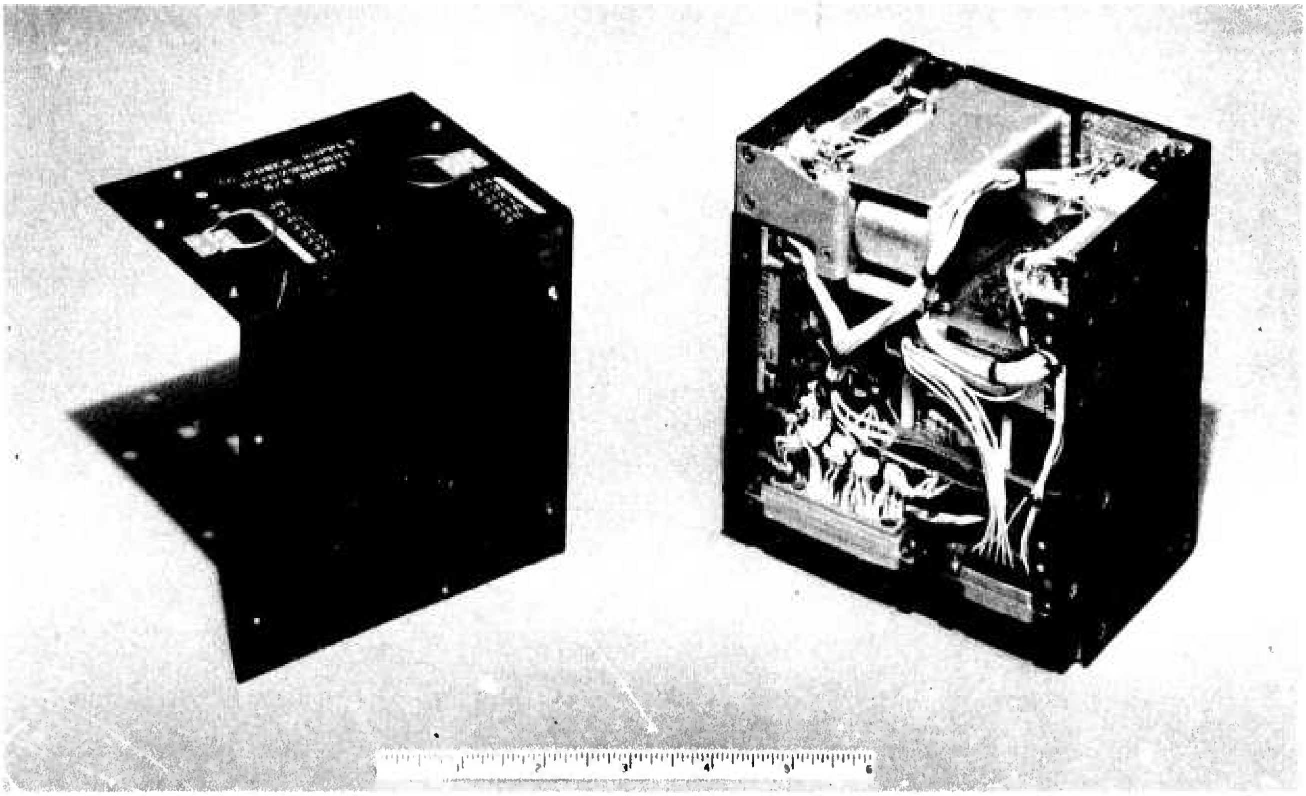


Figure 14. AC Power Supply

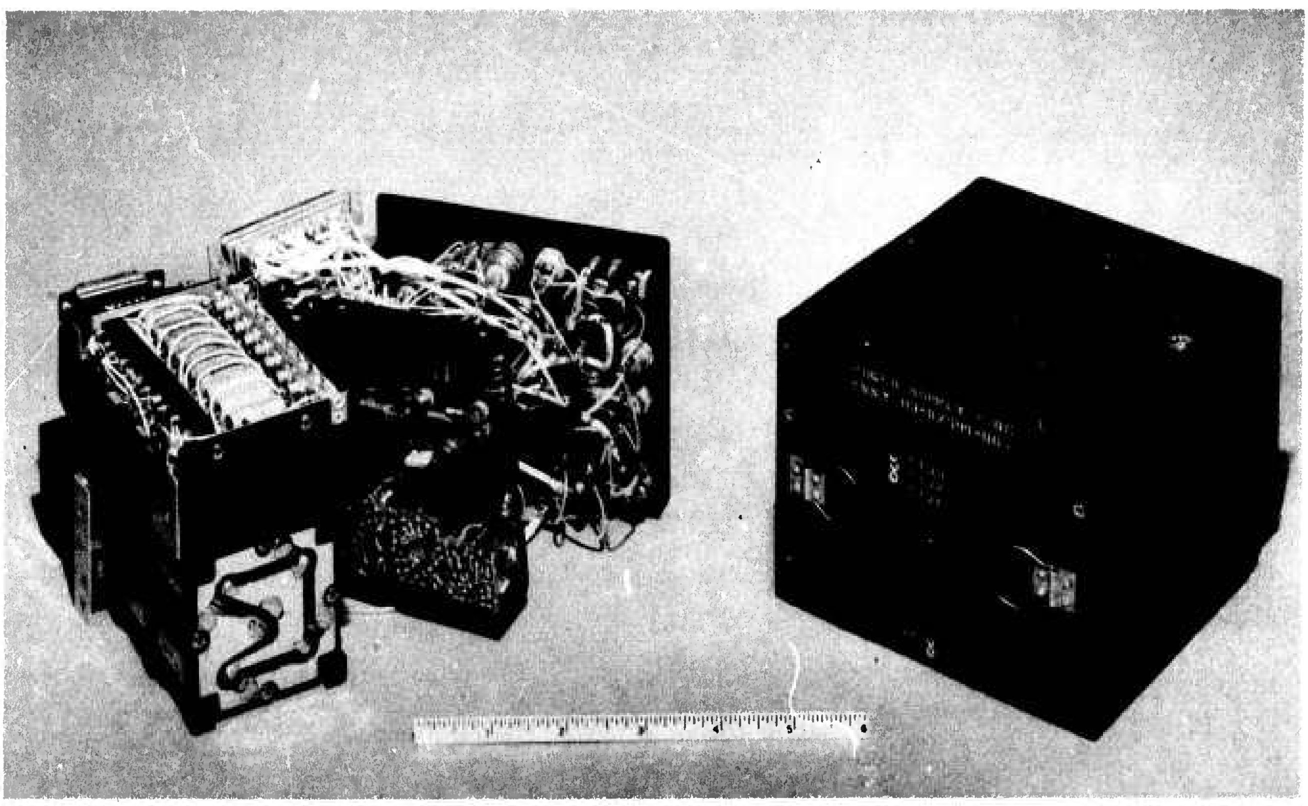


Figure 15. DC Power Supply

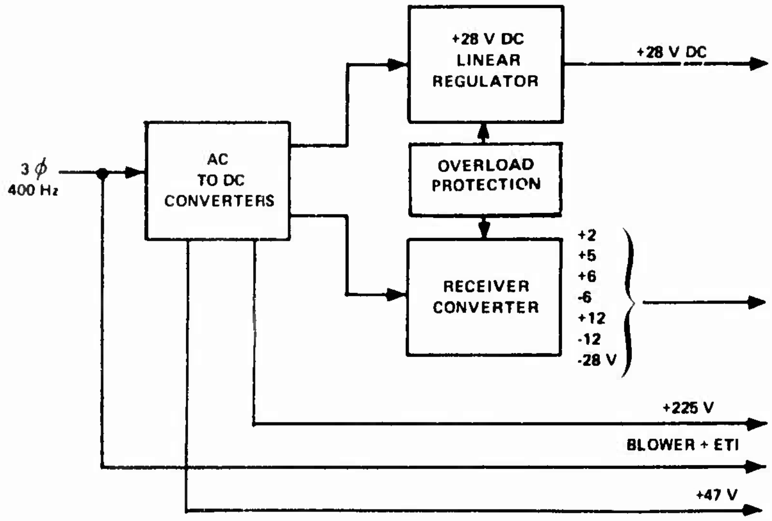


Figure 16. AC Power Supply Block Diagram

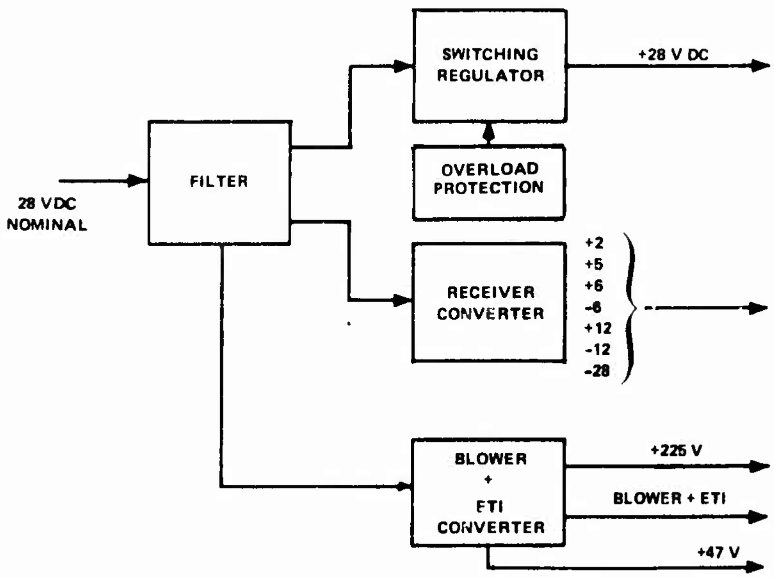


Figure 17. DC Power Supply Block Diagram

Testing with the AC supply went smoothly during the design and Radio Set integration phases. Overall efficiency under full load conditions of the first deliverable supply was as follows:

- Low line voltage 71% efficient
- Nominal line voltage 66% efficient
- High line voltage 63% efficient

Regulation of the 28 VDC regulator under worst case combination of line voltage and load was as follows:

- Receive-high line 28.41 VDC
- FM transmit-low line 28.00 VDC

Progress on the DC supply after the breadboard phase was continually hampered with failures of the switching power transistors and their drivers. Packaging of the DC supply was extremely critical due to the density of parts and switching circuitry involved. After many changes, usually involving routing

and grounding of leads, the DC supply finally emerged as a reliable working unit. Environmental and integration testing of the finalized package was conducted without any failures or problems. Overall efficiency under full load conditions was as follows:

- Low line voltage 72%
- Nominal line voltage 71%
- High line voltage 69%

Regulation of the 28 VDC regulator under worst case combination of line voltage and load was as follows:

- Receive and high line 28.4 VDC
- FM transmit and low line 27.4 VDC

9. AM DETECTOR

Figure 18 shows the AM Detector with one PC board displaced. The basic function of the AM Detector is to detect amplitude modulation on the 8.8 MHz IF signal. Other functions such as squelch, AGC, noise blanking and power amplification are also incorporated. The addition of 25 kHz channel spacing required modifications to the squelch circuitry. While the module was going through a relay out, the existing noise limiter was replaced with a more effective noise blanker.

The RF signal from the IF Amplifier is applied to the AM Detector buffer amplifier (see block diagram, Figure 19). The buffer amplifier amplifies the signal to a level where a conventional diode detector extracts the audio information. The information signal is then passed through a noise blanker, filtered by a 4 kHz-cutoff low-pass filter and routed to a power amplifier. In the power amplifier, the power level is raised to a maximum of 250 milliwatts. From the AM Detector, the audio signal is sent to the aircraft intercommunication set. Output from the diode detector is also routed to the squelch and AGC circuits through additional noise blanker switches. Noise blanking in front of the squelch and AGC circuits is required to ensure normal operation in a noisy environment.

The squelch circuit employs a "carrier-to-noise" detection circuit. The monitored noise power has a bandwidth of approximately 5 kHz.

Changes in the squelch circuits to accommodate 25 kHz channel spacing essentially required the squelch circuit high-pass filter cutoff to be increased from 5 kHz to 10 kHz. Together with narrowing of the IF bandwidth, the noise passband was reduced from a passband of 5 kHz -to- 20 kHz to a passband of 10 kHz -to- 15 kHz. To compensate for the reduction in noise power, the noise amplifier gain was increased. Testing of the new AM Detector has given a measured carrier-to-noise squelch adjustment range of 2 dB to 30 dB.

Impulse noise performance of a receiver can be enhanced by incorporating noise limiting circuits. The old AM Detector design used this method. Figure 20 shows the improvement in SINAD ratio with and without a noise limiter. An even greater improvement in SINAD can be realized by using a noise blanker.

During the redesign of the AM Detector, the noise limiter was replaced with a noise blanker. Figure 20 shows a comparison of both methods. For a 3.5 dB reduction in SINAD the noise limiter gives a 10 dB improvement. Under the same conditions, the noise blanker gives a 30 dB improvement over the noise limiter and a 40 dB gain over no protection.

10. DATA CONVERTER

The Data Converter (Figure 21) interfaces the serial data stream between the control box and the Radio Set. A block diagram of the Data Converter is shown in Figure 22.

The decoder changes pulse width modulation data into binary non-return to zero (NRZ) data. The binary data is placed in a shift register and a sync pulse is generated at the end of each frame. Parity is then checked, and if the data is acceptable, it is shifted into the storage register in parallel.

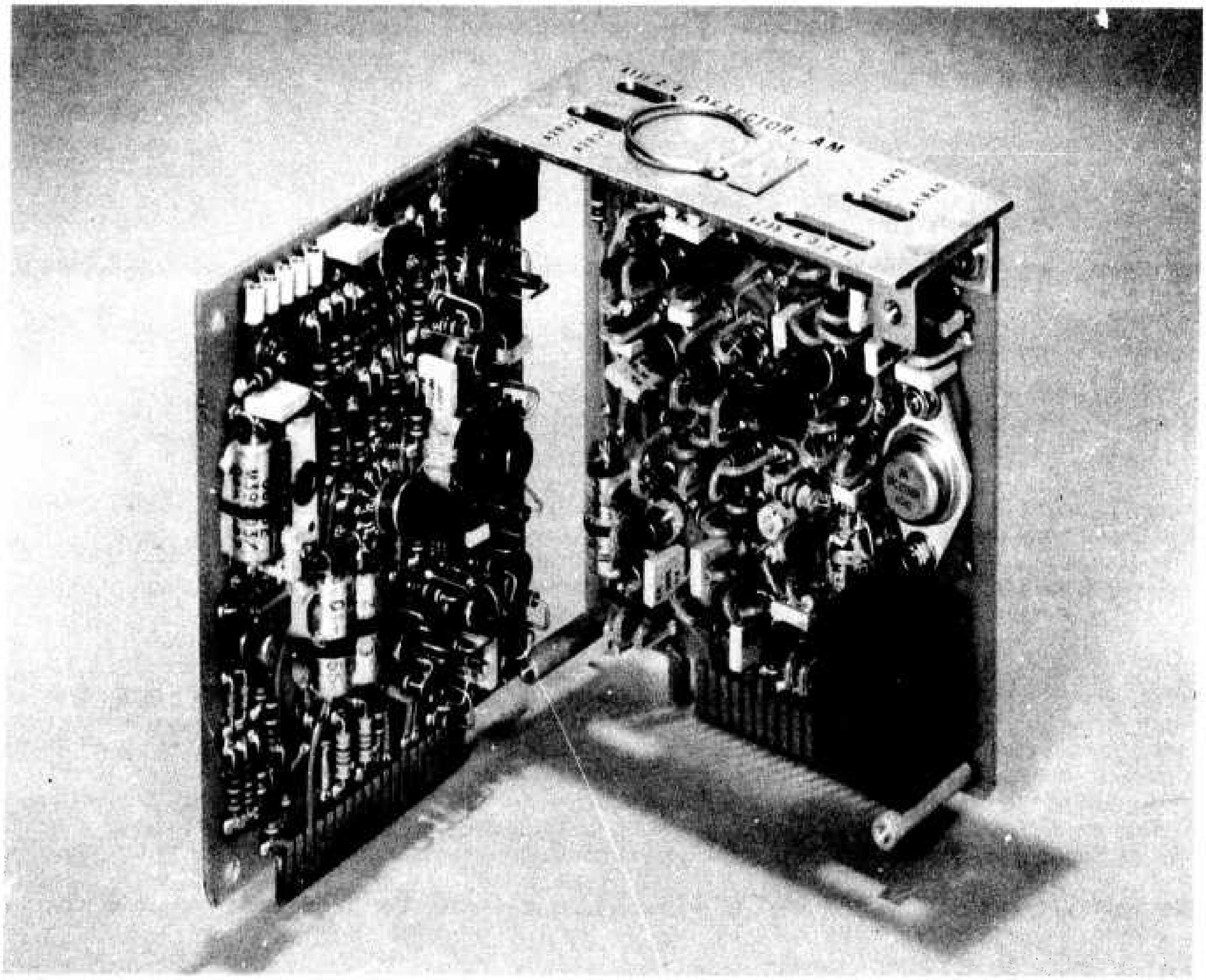


Figure 18. AM Detector

In the Satellite Modes, frequency information is provided to the arithmetic unit where it is modified to reflect the satellite offset frequency. The codes for the three different offsets are prewired in the offset programmer. Selection, as to which of the three offsets is to be used, is made at the Radio Set Control and is sent to the Data Converter as part of the R/T logic (mode) information. The resultant frequency from the arithmetic section is then sent to the Synthesizer.

Mode information not only selects the appropriate offset frequency but also sets the proper operational mode of the Radio Set. Functions of the R/T Logic Unit include Receiver/Transmitter interlock and control box function decoding.

Modifications to the Data Converter for this program include coding changes in the shift register and storage units, R/T logic control function changes, and the addition of the arithmetic section and offset programmer.

Division of the circuitry onto three printed circuit boards is shown by the dashed lines in Figure 22. Because of the many inputs and outputs, the cards were made to plug into each other as well as the R/T Chassis.

For any particular mode on which the Radio Set is used, there are several available controls external to the Radio Set which must be set properly to achieve the desired results. When the AM Mode is selected, the operator may choose either secure, KY-28, or normal AM operation. If the AM mode is chosen and the external modem switch is "on," the desired communication link, most likely, will not

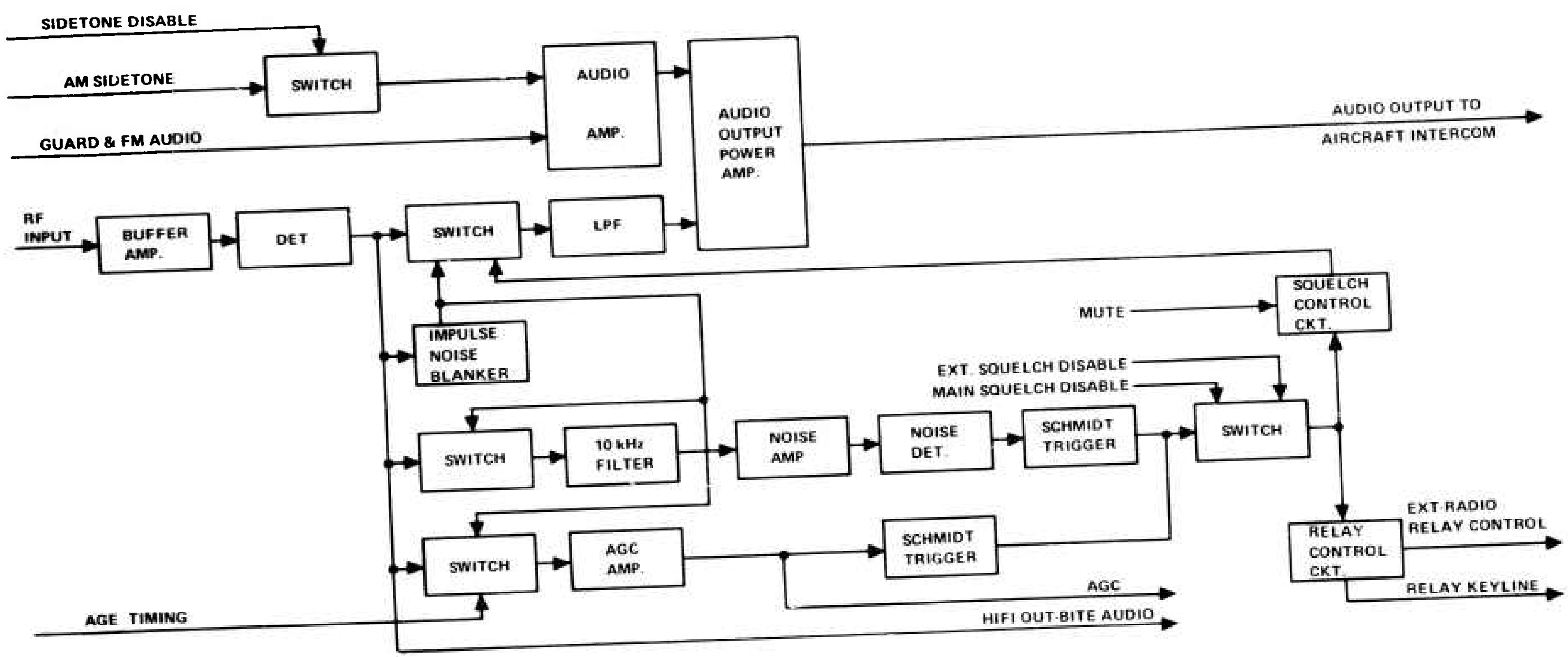


Figure 19. AM Detector Block Diagram

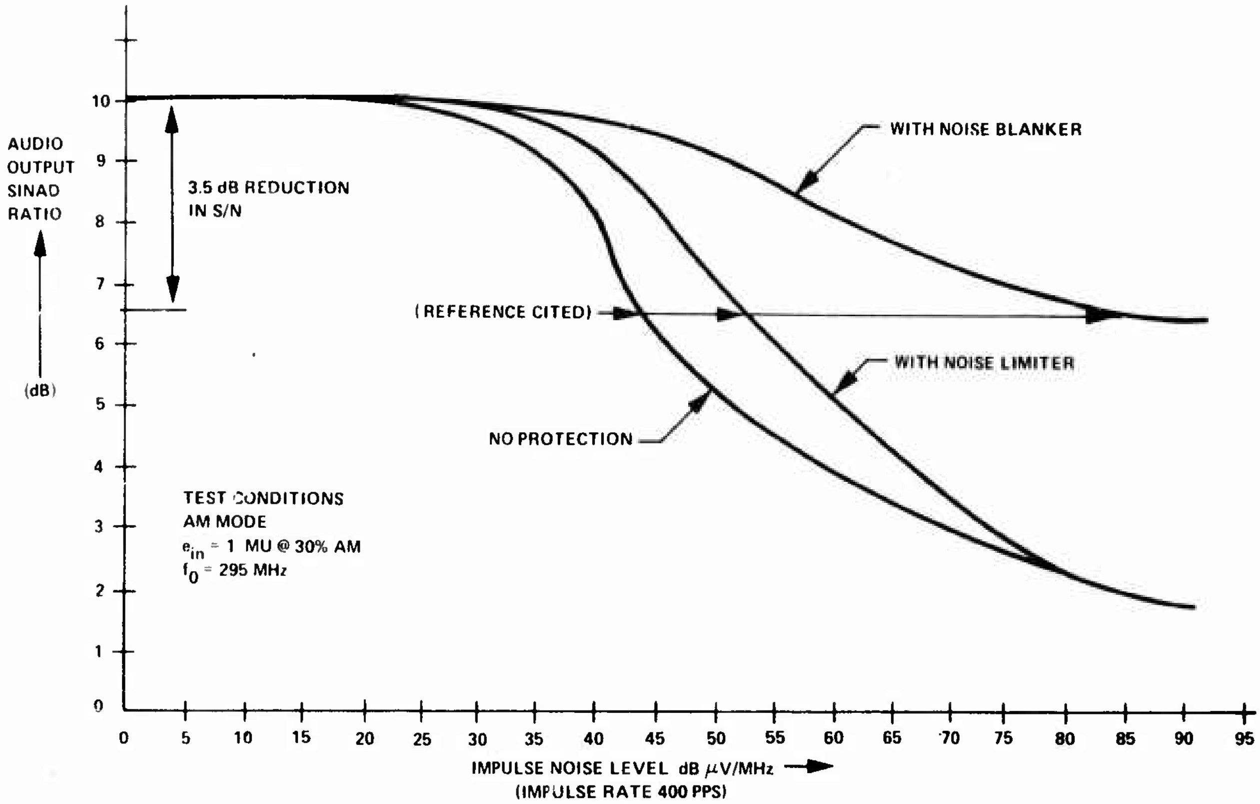


Figure 20. Impulse Noise Rejection Tests

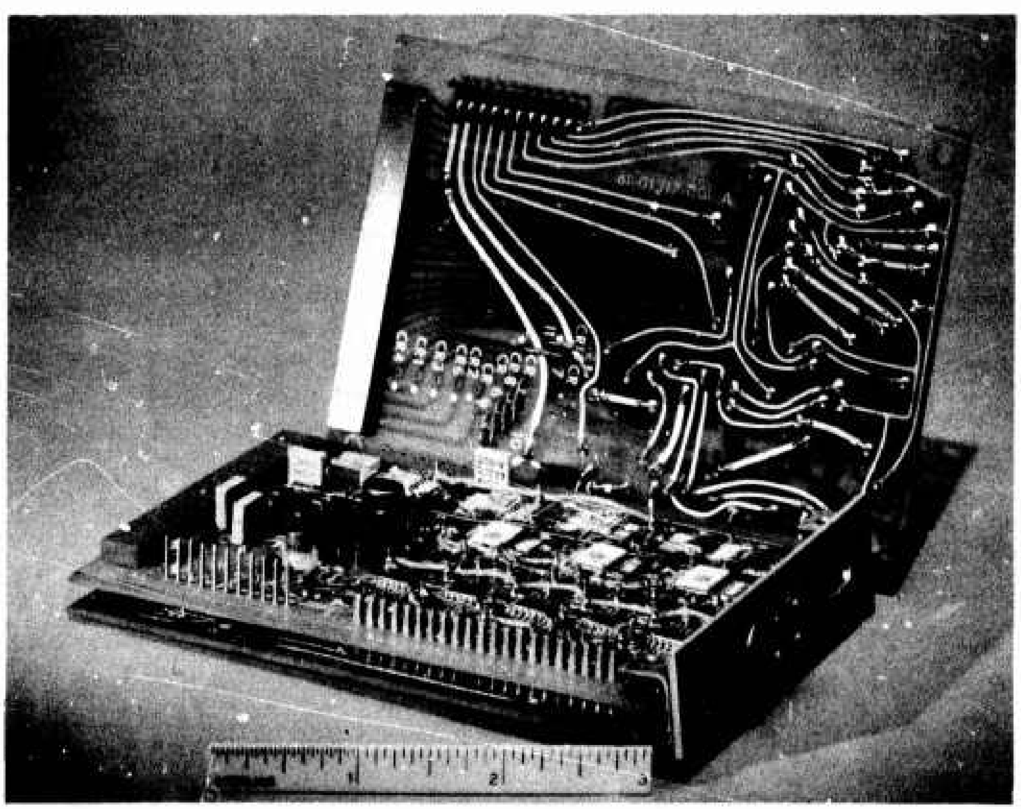


Figure 21. Data Converter

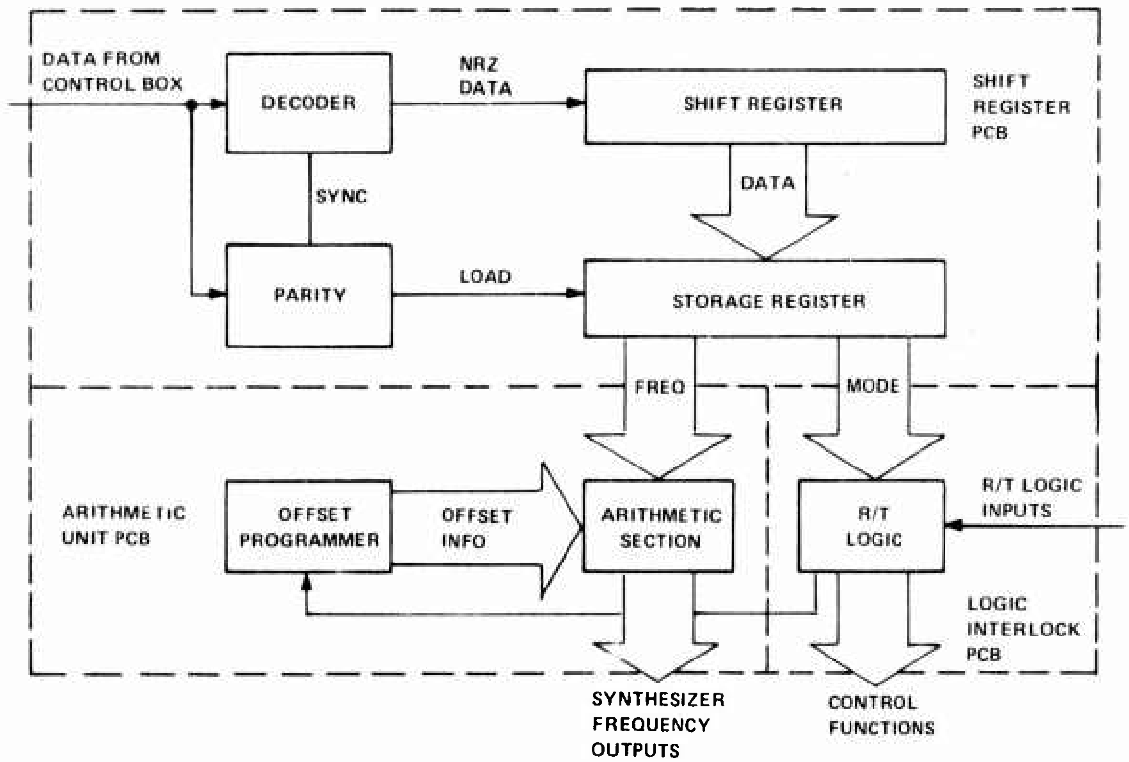


Figure 22. Data Converter Block Diagram

be established. Table IV gives the Data Converter outputs in the SAT-2 mode for all other possible combinations of control settings. For every desired combination of control settings there are 23 possible undesired combinations.

While testing the Data Converter and the Radio Set, several problem areas were uncovered which were directly attributed to the Data Converter. All of these were corrected with minor circuit changes.

11. AUDIO PROCESSOR

To reduce the narrowband AM occupied bandwidth to the 12 kHz requirement of MIL-STD-188B, improved baseband filtering was accomplished in the Audio Processor.

Figure 23 shows a block diagram of the Audio Processor. An existing RC low-pass filter was replaced with a passive three-pole, two-zero elliptic-function low-pass filter. The location of the low-pass filter in the Transmitter modulation scheme allows the response of the filter to characterize the emitted spectrum of the Transmitter in the AM Mode.

Design of the filter was chosen to give a 1 dB maximum passband ripple and a minimum of 20 dB attenuation at 6 kHz. These parameters were chosen to give the best filter performance consistent with the space available in the Audio Processor module. Figure 24 shows the Audio Processor module with the elliptic-function filter incorporated. As can be seen by examining the picture, all practical space available has been used.

Testing the Audio Processor as a unit gave the frequency response as shown in Figure 25 by the dashed line. The solid curve shows the measured frequency response of the Transmitter in the AM Mode. Data for the solid curve was taken by varying the audio frequency at the Radio Set audio input and measuring the relative level of the detected AM on the Transmitter carrier. For all practical purposes, the two curves are identical. The system (solid line) response does, however, level off at -50 dB down. This level represents the close in carrier-to-noise ratio of the Transmitter.

Table IV. Possible Data Converter Outputs for SAT 2 Mode

CONTROL SETTINGS	DATA CONVERTER OUTPUTS																													
	SAT 1	SAT 2	SAT 3	MAIN AUDIO MUTE	IF WIDE BAND	FM CONTROL	T/A INHIBIT	FSK ENABLE	FM LOGIC	GUARD AUDIO MUTE	AM SIDETONE DISABLE	SAT	TONE	XMIT T/A	KY-28 ENABLE	ANT PREAMP INTL.	SYNTX	SYN XMIT	BITE XMIT	XMIT CONT.	SYN EXT MODEM	EXT TONE	EXT MODEM	KY-28	KEY LINE	GUARD R/T CONT.	MAIN SQUELCH DISABLE	TEST BIT	BITE TURNAROUND	PREAMP
REC.	1	0	1	0	1	0	0	0	0	1	0	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	0	0	1
XMIT	1	1	1	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	1	1	1	1	0	1	1	0	0	0
TONE	1	0	1	0	1	0	0	0	0	0	1	1	0	1	1	1	0	0	1	0	1	0	1	1	1	1	1	0	0	1
GD. REC.	1	0	1	0	1	0	0	0	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	0	1	0	0	1
GD. XMIT	1	1	1	0	1	0	0	0	1	0	1	0	1	0	1	0	0	0	1	0	1	1	1	1	0	0	1	0	0	0
GD. TONE	1	0	1	0	1	0	0	0	1	0	1	1	0	1	1	1	0	0	1	0	1	0	1	1	1	0	1	0	0	1
EM. REC.	1	0	1	0	1	1	0	0	0	1	0	1	1	1	1	1	1	1	0	1	0	1	0	1	1	1	1	0	0	1
EM. XMIT	1	1	1	0	1	1	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	1	0	1	0	1	1	0	0	0
EM. TONE	1	0	1	0	1	1	0	0	0	0	1	1	0	1	1	1	0	0	1	0	0	0	0	1	1	1	1	0	0	1
KY-28 REC.	1	0	1	0	0	0	0	0	1	1	0	1	1	1	0	1	1	1	0	1	1	1	1	0	1	1	1	0	0	1
KY-28 XMIT	1	1	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	1	1	1	0	0	1	1	0	0	0
KY-28 TONE	1	0	1	0	0	0	0	0	1	1	0	1	1	1	0	1	1	1	0	1	1	0	1	0	1	1	1	0	0	1
GD. EM. REC.	1	0	1	0	1	1	0	0	1	1	1	1	1	1	1	1	1	1	0	1	0	1	0	1	1	0	1	0	0	1
GD. EM. XMIT	1	1	1	0	1	1	0	0	1	0	1	0	1	0	1	0	0	0	1	0	0	1	0	1	0	0	1	0	0	0
GD. EM. TONE	1	0	1	0	1	1	0	0	1	1	1	1	0	1	1	1	0	0	1	0	0	0	0	1	1	0	1	0	0	1
KY-28 EM. REC.	1	0	1	0	0	1	0	0	1	1	0	1	1	1	0	1	1	1	0	1	0	1	0	0	1	1	1	0	0	1
KY-28 EM. XMIT	1	1	1	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0	1	0	0	1	0	0	0	1	1	0	0	0
KY-28 EM. TONE	1	0	1	0	0	1	0	0	1	1	0	1	1	1	0	1	1	1	0	1	0	0	0	0	1	1	1	0	0	1
GD. KY-28 REC.	1	0	1	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	1	0	1	0	0	1
GD. KY-28 XMIT	1	1	1	0	0	0	0	0	1	0	1	0	1	0	1	0	0	0	1	0	1	1	1	0	0	0	1	0	0	0
GD. KY-28 TONE	1	0	1	0	1	0	0	0	1	0	1	0	0	1	1	1	0	0	1	0	1	0	1	0	1	0	1	0	0	1
GD. EM. KY-28 REC.	1	0	1	0	1	1	0	0	1	1	1	1	1	1	1	1	1	1	0	1	0	1	0	0	1	0	1	0	0	1
GD. EM. KY-28 XMIT	1	1	1	0	1	1	0	0	1	0	1	0	1	0	1	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0
GD. EM. KY-28 TONE	1	0	1	0	1	1	0	0	1	0	1	1	1	1	1	1	0	0	1	0	0	0	0	0	1	0	1	0	0	1

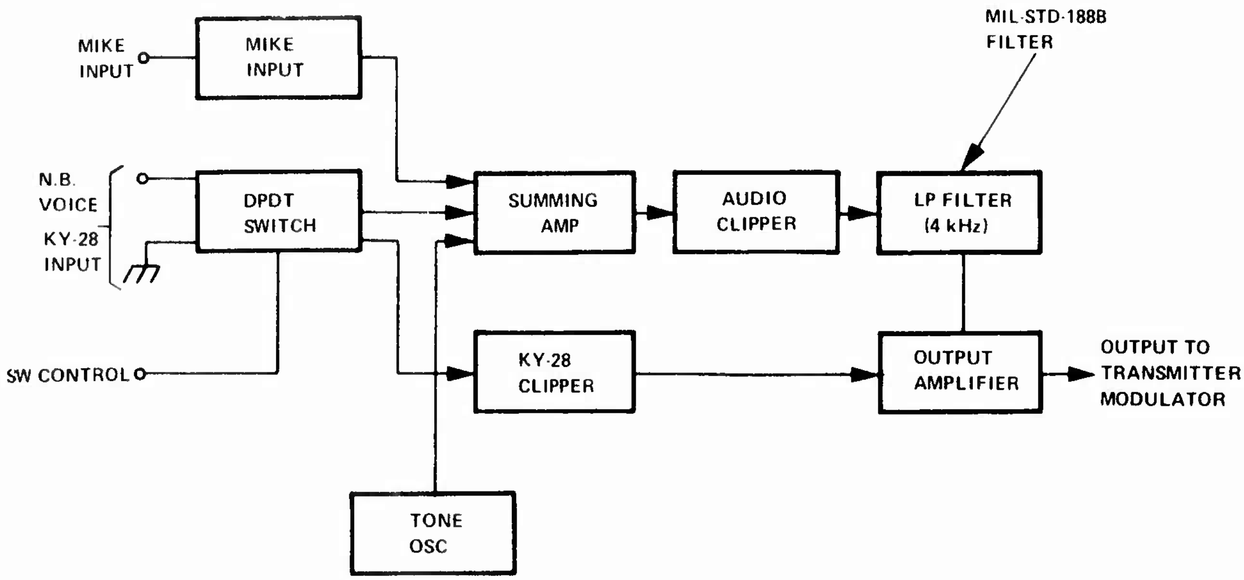


Figure 23. Audio Processor Block Diagram

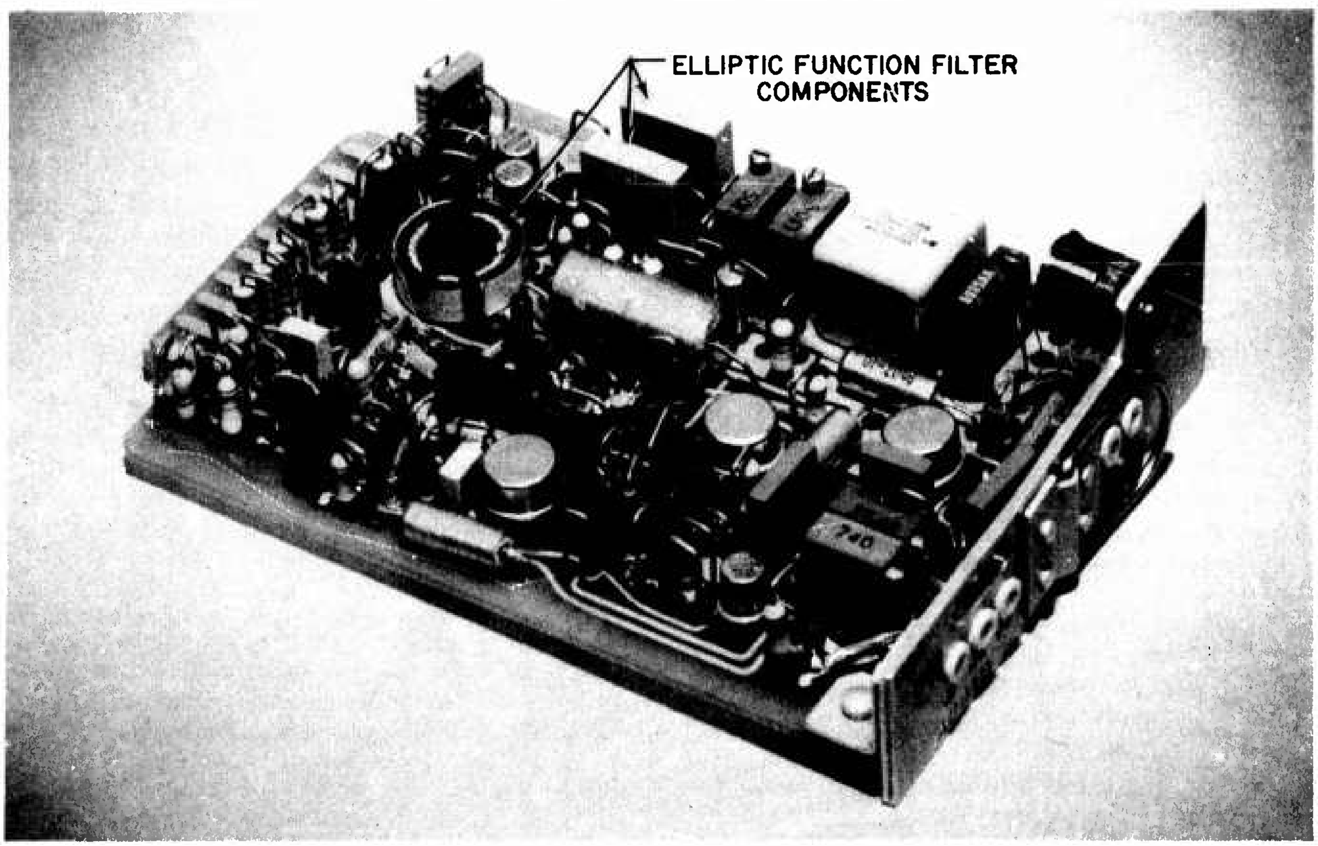


Figure 24. Finalized Audio Processor Module

During the integration and test phase of the program, measurements of the percent negative modulation versus audio input were also taken. Results of these tests indicate the audio clipper circuit (see Figure 23) does not keep the negative modulation to within the same limits as before. The response characteristics of the elliptic-function filter are such as to exhibit a 10% overshoot for a squarewave input. For AM narrowband inputs to the Radio Set of 6 VRMS, the audio clipper reshapes the signal essentially into a squarewave. Therefore, the audio clipper now will only hold the negative percent modulation to within 90% ±10% instead of 95% ±5% for signal inputs of 1.4 to 6 VRMS. The net result is a minor decrease in effective modulation during actual operation.

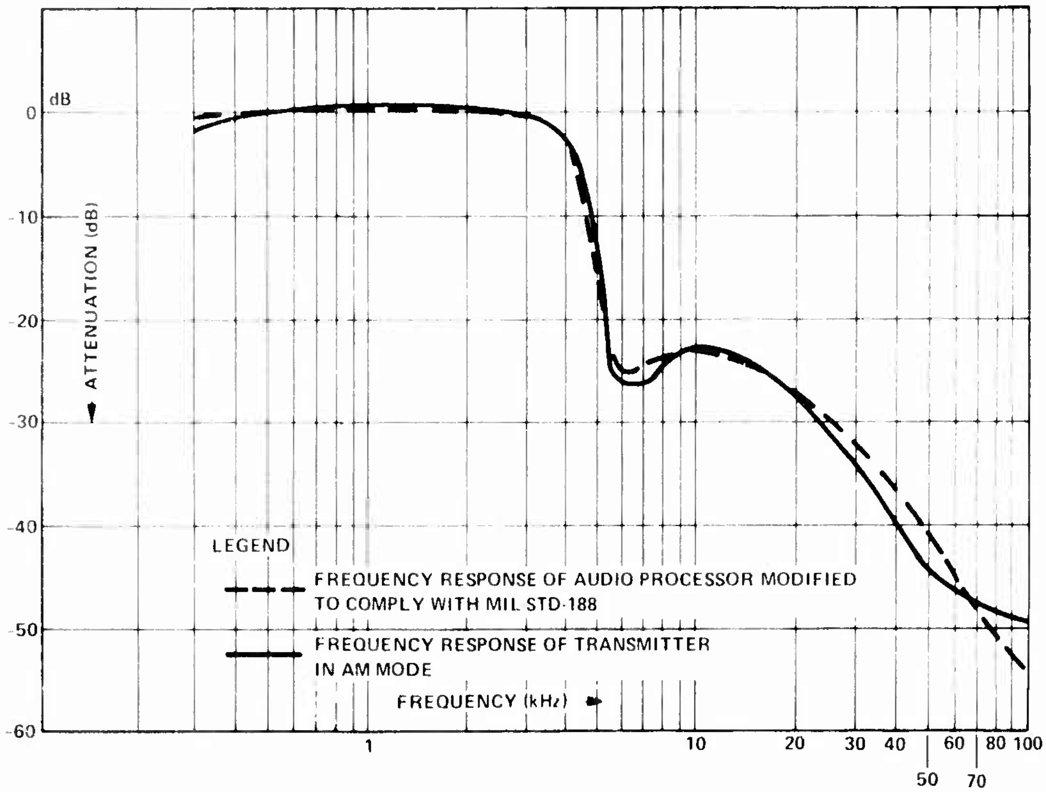


Figure 25. Audio Processor and Transmitter Frequency Response Graphs

12. FM PROCESSOR

The FM Processor module (Figure 26) performs interfacing, processing, and gating functions on the Radio Set Aircraft Intercommunication input and output signals during the Satellite Mode of operation.

In receive, the FM Processor input is a wideband detected audio signal taken from the FM/FSK Detector. Figure 27 traces the receive signal path, shown by the heavy line, through the processor module. The received signal is buffered, routed through a 4 kHz cutoff lowpass filter, de-emphasized, and amplified. Following the amplifier, the processed audio is sent to the AM Detector where it is again amplified and applied to the Radio Set Aircraft Intercommunication input.

For Satellite Mode Transmit, Figure 27 shows the signal path as a heavy dotted line. A signal from the aircraft intercom is first routed through the Audio Processor and then fed to the FM Processor. The Audio Processor presents the intercom set with a balanced input, matches the signal to the FM Processor input during the FM Voice Modes, and FM Tone transmit. The Audio Processor supplies the FM Processor with a 1020 Hz signal for tone modulation. In the FM Processor, the incoming signal is buffered, pre-emphasized, clipped, and routed through a 4 kHz cutoff lowpass filter. From the FM Processor the signal is sent to the Synthesizer where Transmitter carrier FM modulation occurs.

Figures 28 and 29 show the normalized response of a signal passing through the FM Processor during both the Receive and Transmit Modes. The de-emphasis and pre-emphasis used is quite easily noted as 6 dB per octave. Above 4 kHz, the processor lowpass filter rapidly attenuates both the receive and transmit signals.

Squelch circuitry for the receiver in the Satellite Mode is also contained in the FM Processor. A portion of the wideband detected audio signal is used for a FM noise power squelch circuit. FM noise power is measured in the audio baseband region of 10 to 15 kHz. A carrier received on channel will "quiet" this noise power. At carrier-to-noise ratios of 10 dB (nominal) the noise detector output will open the squelch. This basic squelch approach has the advantage of immunity to a noise environment, such as,

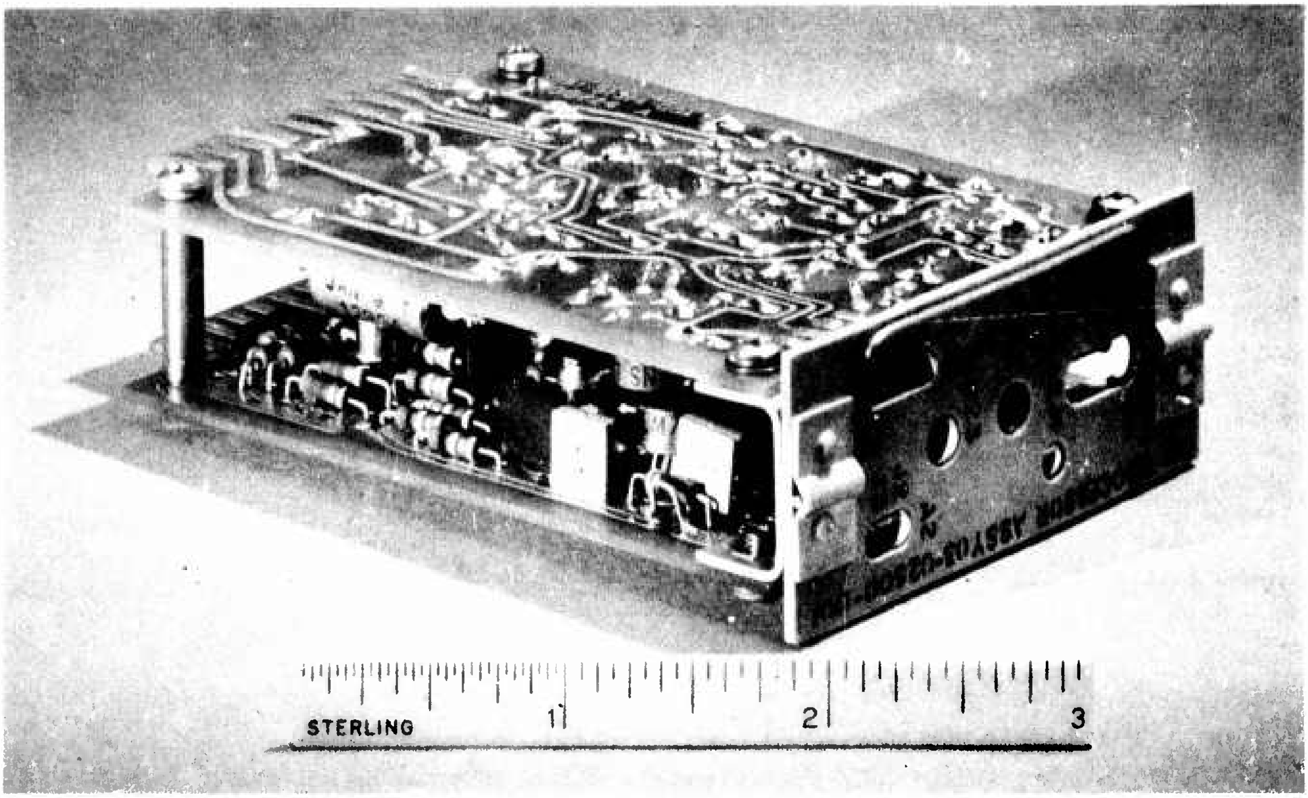


Figure 26. FM Processor

the presence of static bursts or other noise sources. However, multiple carriers received simultaneously or spectrums received containing wideband information (such as FM data) will block the noise circuitry, causing the receiver to remain squelched. To eliminate this problem, a second input is presented to the FM squelch gate. This unsquelch command is generated in the AM Detector. Similar noise circuitry is employed which detects the absence of AM noise power. If a wideband FM signal is received which "blocks" the FM noise detector, the AM noise detector will open the FM squelch. If a signal or signals are received that have spectrums which block both noise circuits (AM and FM), a third control will open the squelch. This signal is derived from the AGC circuitry - effectively measuring total in-band signal power regardless of content. Presently the circuitry is adjusted for squelch opening at 28 to 78 microvolts at the antenna for the FM Mode of operation. These three basic squelch commands will ensure proper squelch operation regardless of operational conditions, including noise environment, wideband AM and/or FM signal spectrums, or multiple carrier reception.

Testing of the FM Processor in the Radio Set provided results well within all specification requirements. However, the settings of the three interacting squelch circuits had to be compromised somewhat to have acceptable operation in both the Satellite and Normal Modes. Table V shows typical levels at which the three squelch circuits operate during the AM, FM, and Guard Modes. The squelch hysteresis for the FM Satellite Modes was approximately 1.25:1 whereas the hysteresis in the AM Mode was approximately 2:1. Additional switching circuitry will be required to place the FM satellite squelch hysteresis in the more desirable range of 2:1.

Another interesting feature can be noted by examining the AM Detector S/N squelch during FM operation. With a 1000 Hz modulation signal, the AM Detector S/N squelch circuitry appears to function equally as well for FM as for AM.

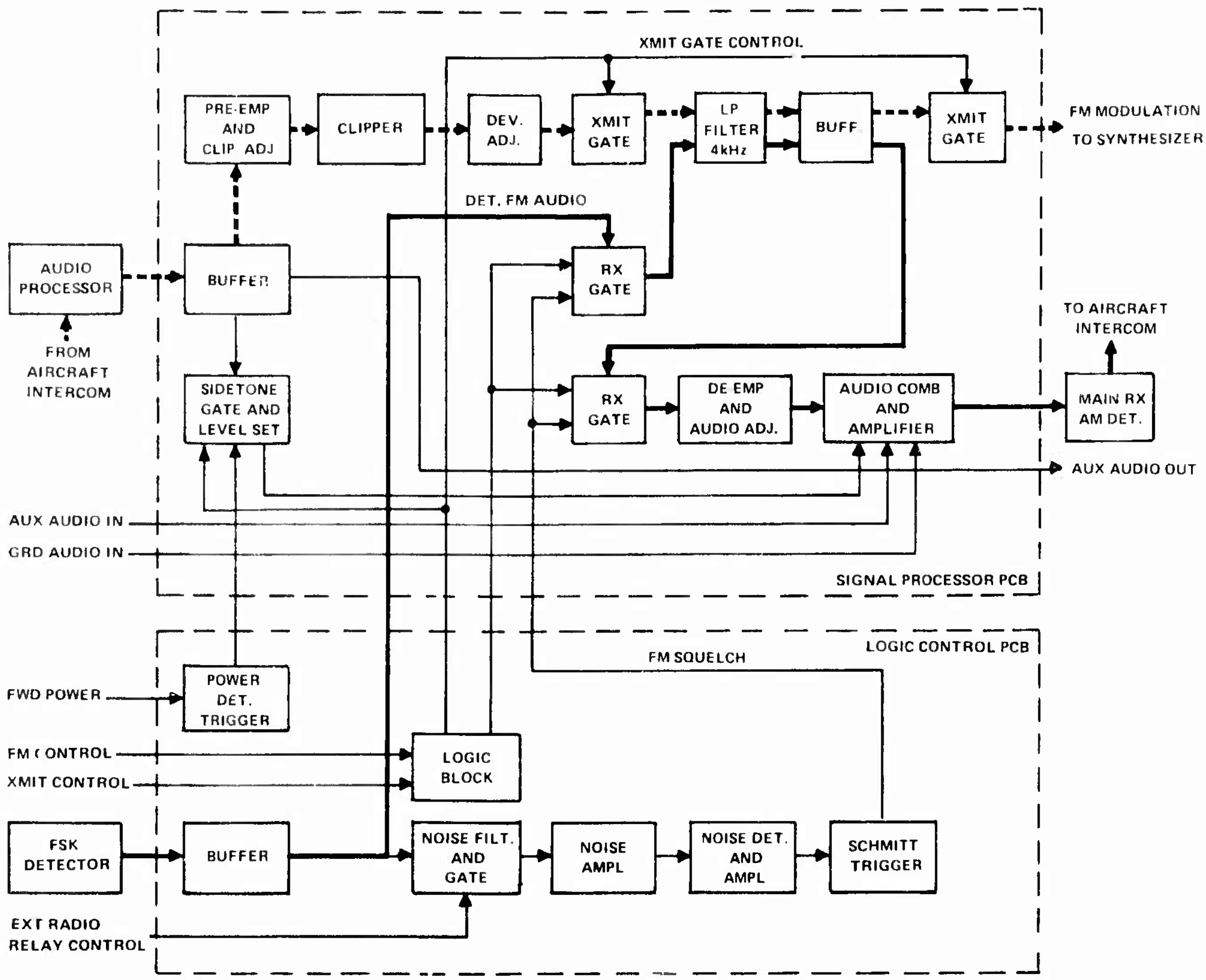


Figure 27. FM Processor Block Diagram

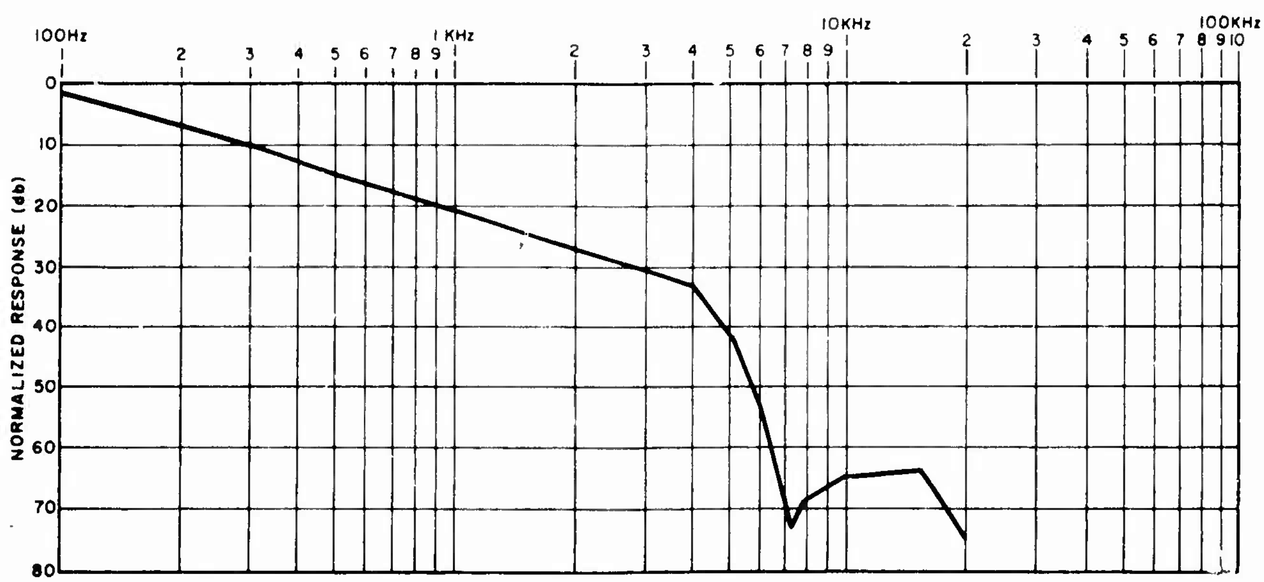


Figure 28. FM Processor Receiver Mode

Table V. Typical Squelch Operating Levels

Main Receiver		In Channel A			Not In Channel A		
		FM Proc. S/N Squelch	AM Det. S/N Squelch	AM Det. AGC Squelch	FM Proc. S/N Squelch	AM Det. S/N Squelch	AM Det. AGC Squelch
AM Mode	Sq. Dis. @ - μv	2.0	2.10	77.0	2.4	2.2	82.0
AM Mode	Sq. En. @ - μv	1.7	0.92	28.0	2.0	1.0	27.0
FM Mode	Sq. Dis. @ - μv	2.1	2.30	78.0	2.2	2.4	80.0
FM Mode	Sq. En. @ - μv	1.8	1.00	28.0	1.8	1.0	26.0
Sat Mode	Sq. Dis. @ - μv	0.82	0.88	03.8	0.9	0.9	4.1
Sat Mode	Sq. En. @ - μv	0.64	0.39	01.3	0.75	0.42	1.45

Guard Receiver		Channel A		Not Channel A	
		AGC Sq.	S/N Sq.	AGC Sq.	S/N Sq.
AM Mode	Sq. Dis. @ - μv	29.0	1.50	140	2.80
	Sq. En. @ - μv	22.0	1.20	100	1.90
Sat Mode	Sq. Dis. @ - μv	1.50	0.84	9.4	0.83
	Sq. En. @ - μv	1.20	0.68	6.3	0.70

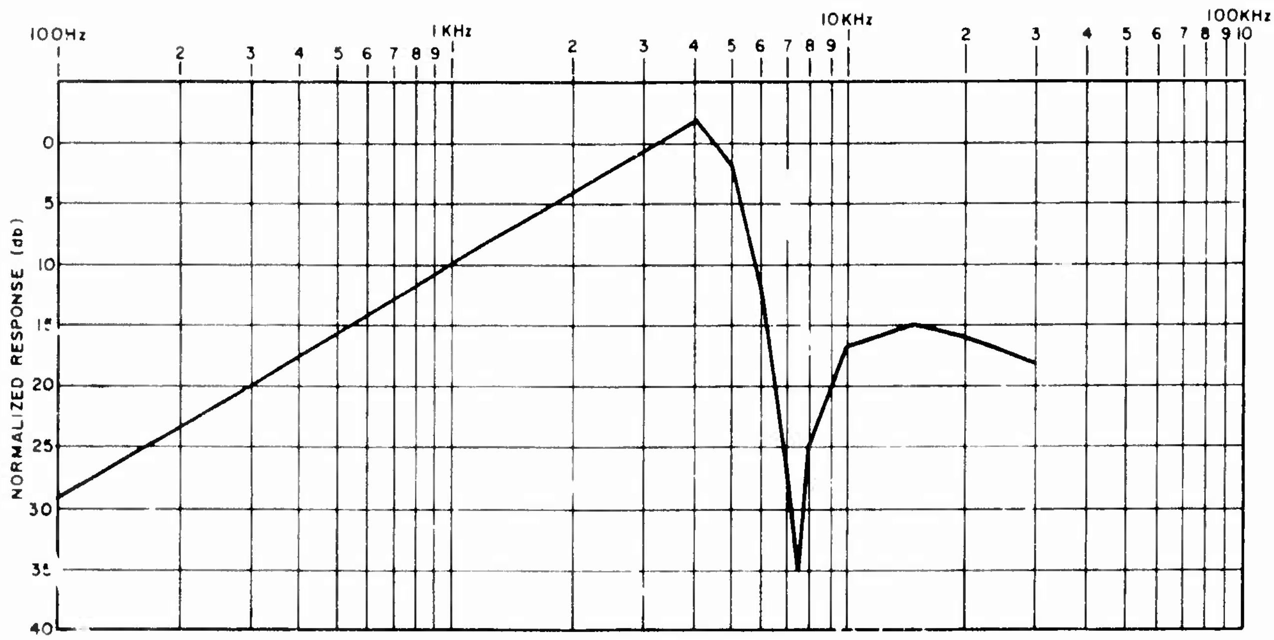


Figure 29. FM Processor Transmit Mode

13. MODEM ADAPTER

The function of the Modem Adapter (Figures 30 and 31) is to combine an externally provided 70 MHz input and the Transceiver 1st local oscillator (synthesizer) frequency. This signal is then used to drive the Transmitter. For other modes of operation, the Synthesizer input is bypassed directly to the module output.

Listed below are the electrical requirements for the Modem Adapter. The most difficult parameter to meet was the spurious product specification. Spurious signals (frequency range of 200 to 400 MHz) generated in the mixing process appear at both the output of the Modem module and the antenna connector of the Transceiver. A major portion of the design and breadboard phases were devoted to the mixing process.

Electrical

Synthesizer Input	365 to 385 MHz @ 0 dBm to +3 dBm
Modem Input	70 MHz ±0.5 MHz @ 0 dBm ±3 dBm
Output	295 to 315 MHz @ 0 dBm ±3 dBm
Input Impedance	50 ohms nominal
Output Impedance	50 ohms nominal
Spurious Products	80 dB below output carrier except for harmonics which shall be at least 20 dB below output carrier
Insertion Loss in the Bypass Mode	Less than 1 dB
Switching Time	Less than 10 microseconds
Switching Command	Ground via a DTL gate for external modem operation

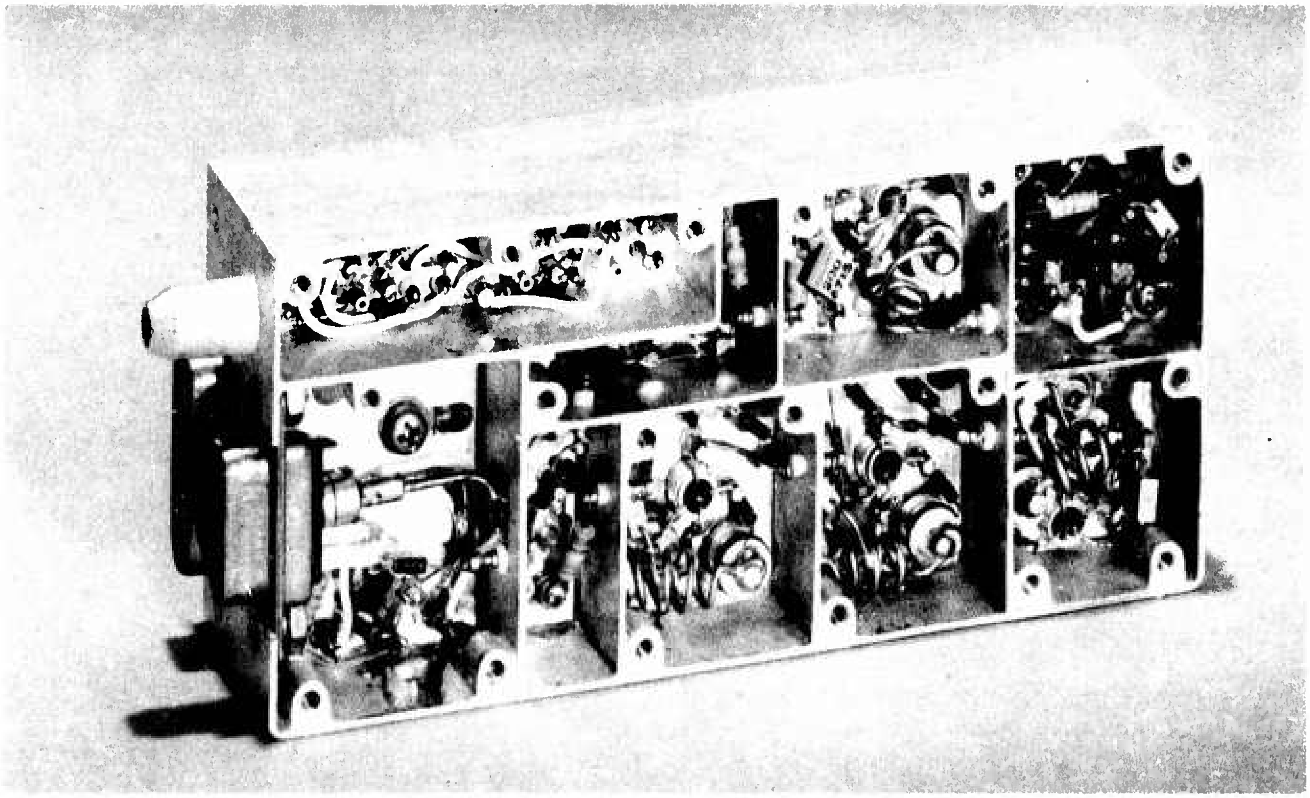


Figure 30. Modem Adapter Module

Power Budget

Voltage	Current	Power
+2 V	20 mA	40 MW
-12 V	20 mA	240 MW

During the breadboard phase, several mixing approaches were tried. These included a MOS FET bridge mixer, a linear mixer, and a double-balanced diode bridge mixer. Each type of mixer was breadboarded and tested. Only the double-balanced diode bridge mixer met all required parameters.

Another critical design consideration was the isolation of the external 70 MHz input to the Modem Adapter module. If the external 70 MHz input signal is coupled into the Main Receiver IF Amplifier, degradation of receiver sensitivity will occur. Several precautions were taken to provide as much isolation as possible. External input and output connectors were physically separated on the front panel. Semi-rigid coaxial cable was used to connect the external modem input and output to the front panel. The Modem module was located next to the front panel to allow for short cable runs to and from the front panel. All sections of the Modem module were physically isolated (see Figure 30) from each other and from other modules in the Radio Set. In modes other than Modem operation, the Modem amplifiers are deactivated.

14. SYNTHESIZER

Synthesizer signal flow is shown in Figure 32. Changes in the Synthesizer to accomplish 25 kHz channel spacing required modification of the pulse groups generated in the programmable divider. Circuits, for the programmable divider were contained on two ceramic logic cards. These cards already had a high density of integrated circuits as can be seen in Figures 33 and 34. To make room for the additional new circuitry, the frequency information code was changed from Wagner to BCD. The code change allowed taking advantage of newly available integrated circuits which reduced the package count from 69 for the old design to 42 for the new design including the 25 kHz modification circuitry. An additional

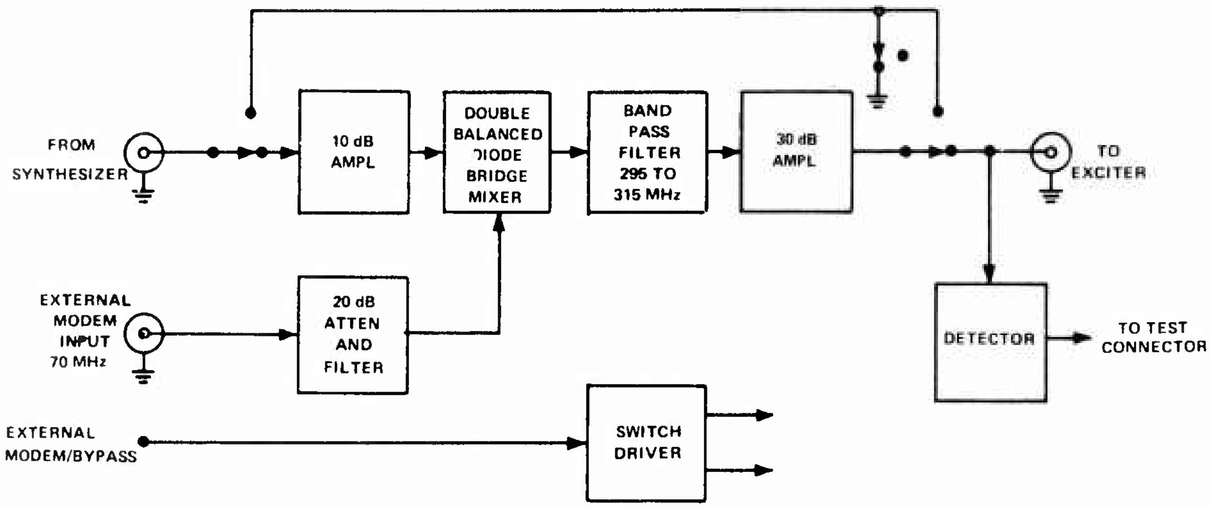


Figure 31. Modem Adapter Module Block Diagram

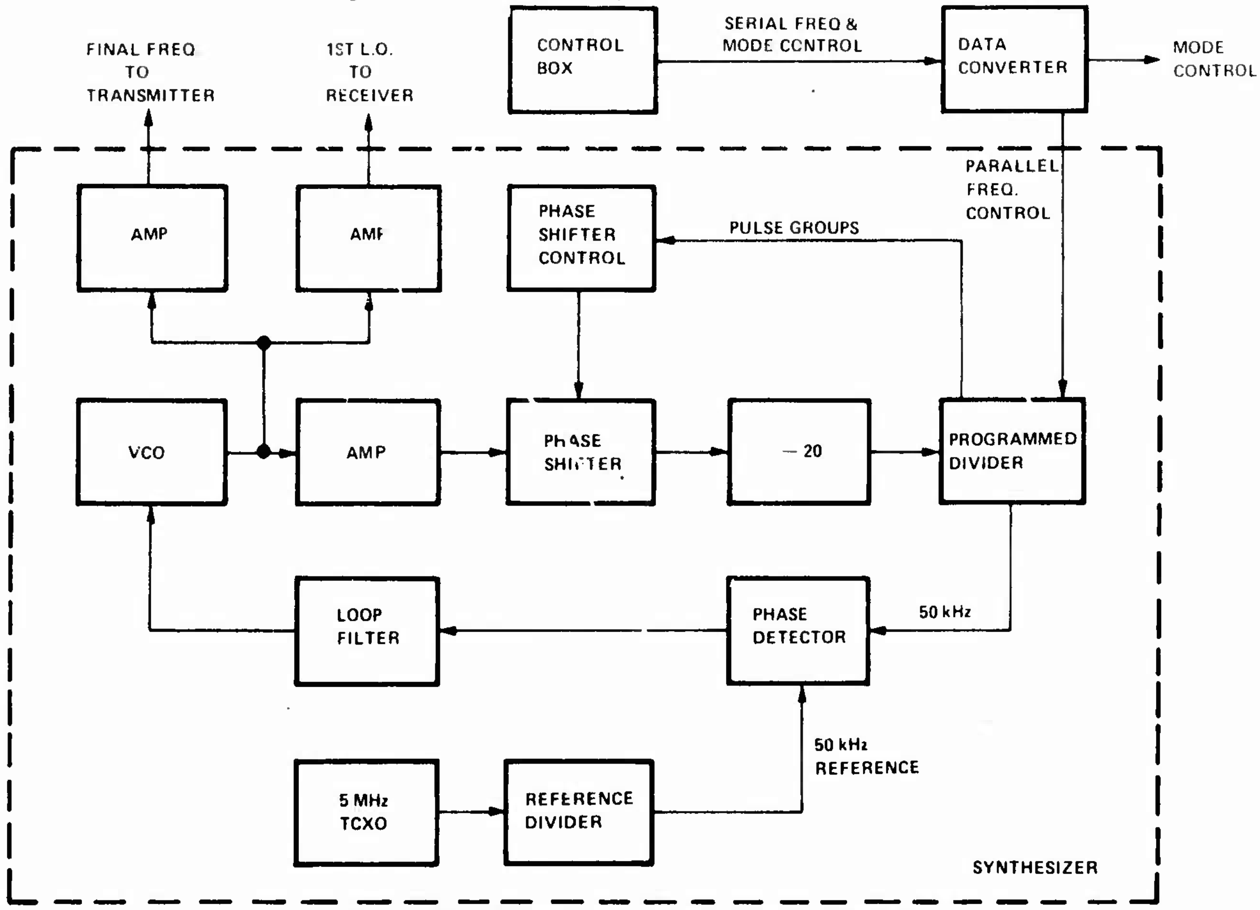


Figure 32. Frequency Control Block Diagram

bonus was gained from the reduction in integrated circuits because the new design fit on three glass epoxy printed circuit cards. The new packaging is easier to implement and less expensive to build.

Implementation of the 25 kHz channel spacing can best be understood by examining the operation of the Synthesizer as shown in Figure 32. A sample of the VCO output (Synthesizer output) is fed through the phase shifter and divide-by-twenty blocks to the programmed divider. Frequency information from the Control Box programs the divider to give a 50 kHz output which is fed into the Phase Detector module. This signal is then compared to the 5 MHz reference TCXO divided down to 50 kHz reference. A difference in the programmed divider output and 50 kHz reference is filtered in the loop filter and sent to

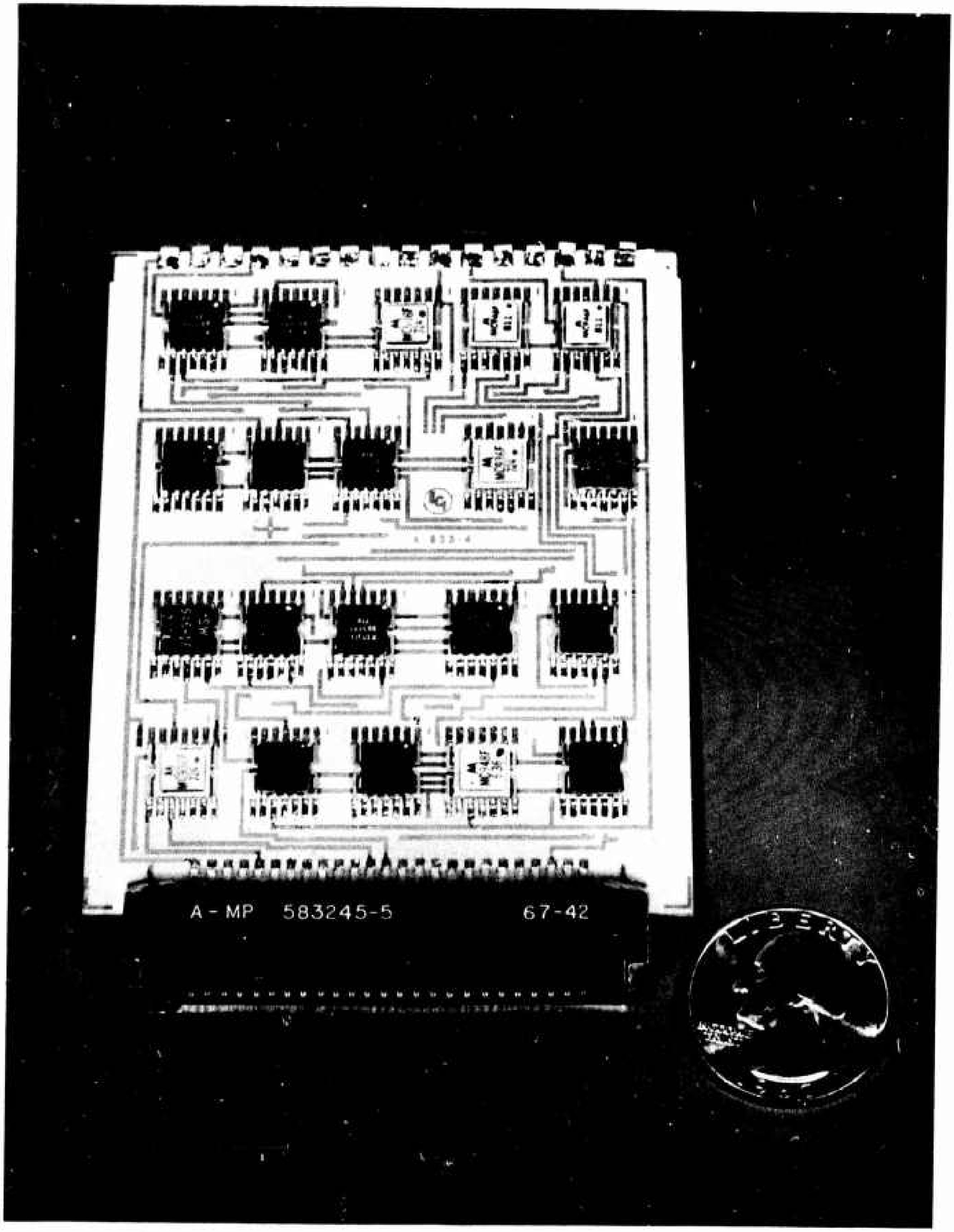


Figure 33. AN/ARC-145 Synthesizer Logic A

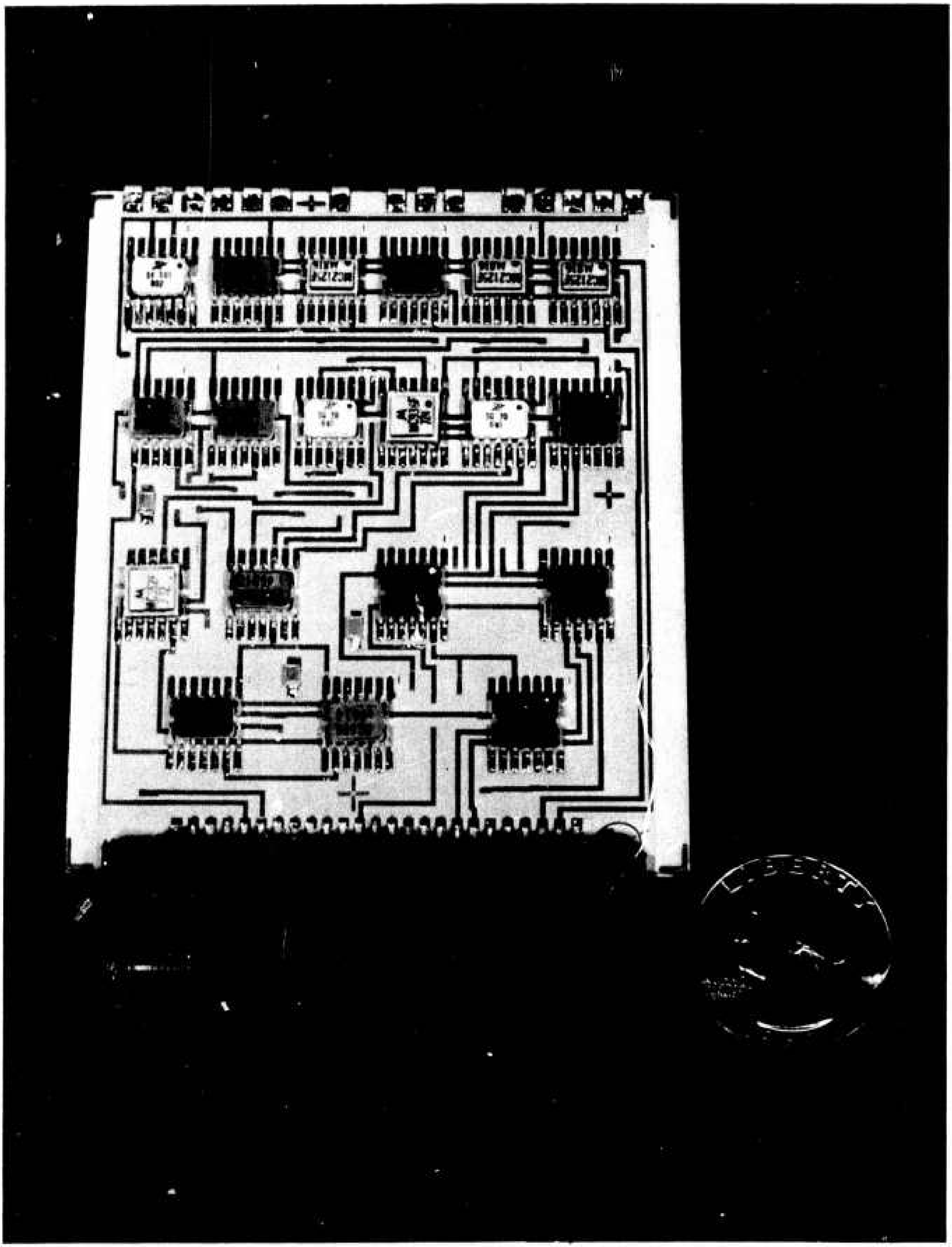


Figure 34. AN/ARC-145 Synthesizer Logic B

the VCO as a correction voltage. The VCO output is then phase locked at the Control Box frequency to the 5 MHz TCXO.

The function of the phase shifter is to control the output frequency in 20 kHz (FSK mode), 25 kHz, 50 kHz, 75 kHz, and 100 kHz increments. Pulse groups, generated by the programmed divider, are applied to the phase shifter to provide a specific amount of phase shift at the VCO output frequency. Each pulse into the phase shifter generates -90 degrees of phase shift, hence four pulses produce one complete cycle (-360 degrees) of phase shift. Thus the phase shifter output is reduced by one cycle. To maintain phase lock, the signal from the loop filter causes the VCO output to increase by one cycle. When four groups are generated at the reference frequency of 50 kHz, then a 50 kHz offset, or increase in output frequency will be obtained. Two groups of four pulses each 50 kHz period, will then supply two cycles of phase shift at a 50 kHz rate or 100 kHz increase in frequency. Twenty-five kHz frequency increases can be introduced, therefore by adding groups of only two pulses at a 50 kHz rate or every 50 kHz period.

Figures 35 and 36 show the final glass epoxy printed circuit boards. Only the synthesizer chassis card guides and the Radio Set card connectors required modification to incorporate the new cards into the radio. All tests using the new cards were completely successful.

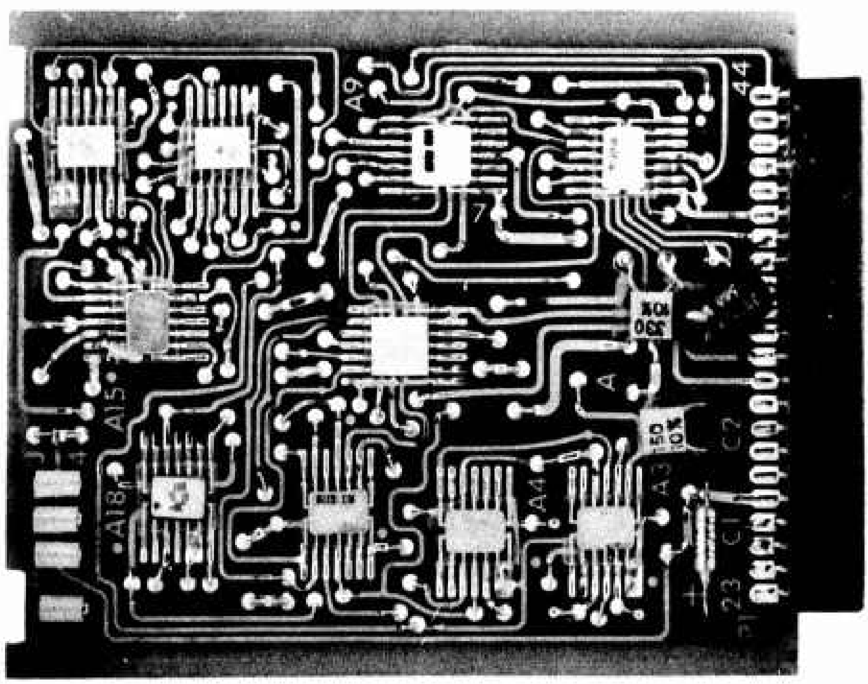


Figure 35. Programmed Divider PC Board

15. CONTROL BOX

A major portion of the information from the Control Box to the Radio Set is sent via serial data streams. The serial data stream consists of 22 information bits, a parity bit, and a sync pulse. For the 1750 channel AN/ARC-145, the 22 information bits consist of the following:

- 14 Frequency Control Bits
- 1 Main Squelch Bit
- 1 Guard Squelch Bit
- 1 ADF Mode Bit
- 1 FSK Mode Bit
- 1 Guard Mode Bit
- 1 BITE Bit
- 2 Spare Bits

In going to 25 kHz channel spacing, the number of spare bits was reduced to one and the number of frequency control bits was increased to 15. Electrically, this meant increasing the number of memory sense amps from 14 to 15 and adding one more bit to each of the 20 words in the actual memory Changes in the front panel required 2 additional selections be included in the hundredths of a megacycle frequency control and display.

Although the modifications required in the Control Box do not sound too complicated, a detailed analysis revealed a major modification would be necessary. Figure 37 shows the left side of the Control Box and the dimension "H" which grew to allow the additional memory storage for 25 kHz channels. Some problems had previously occurred involving the memory connectors. To relieve the connector situation, additional space was allotted to the memory behind the memory connector areas. This required the memory to grow in both the "H" dimension and the "D" dimension. As can be seen from Figure 37, the rear of the hundreds switch already came fairly close to the memory connector. With the additional space needed for the memory, the hundreds switch would then come dangerously close to the memory connector. Figure 38 shows the right side view of a 50 kHz Control Box. The hundredths switch had to be changed from a single deck switch to a double deck switch. Immediately behind the switch were three PC boards (only the top PCB shows) which had to be redesigned to allow room for the larger hundreds switch.

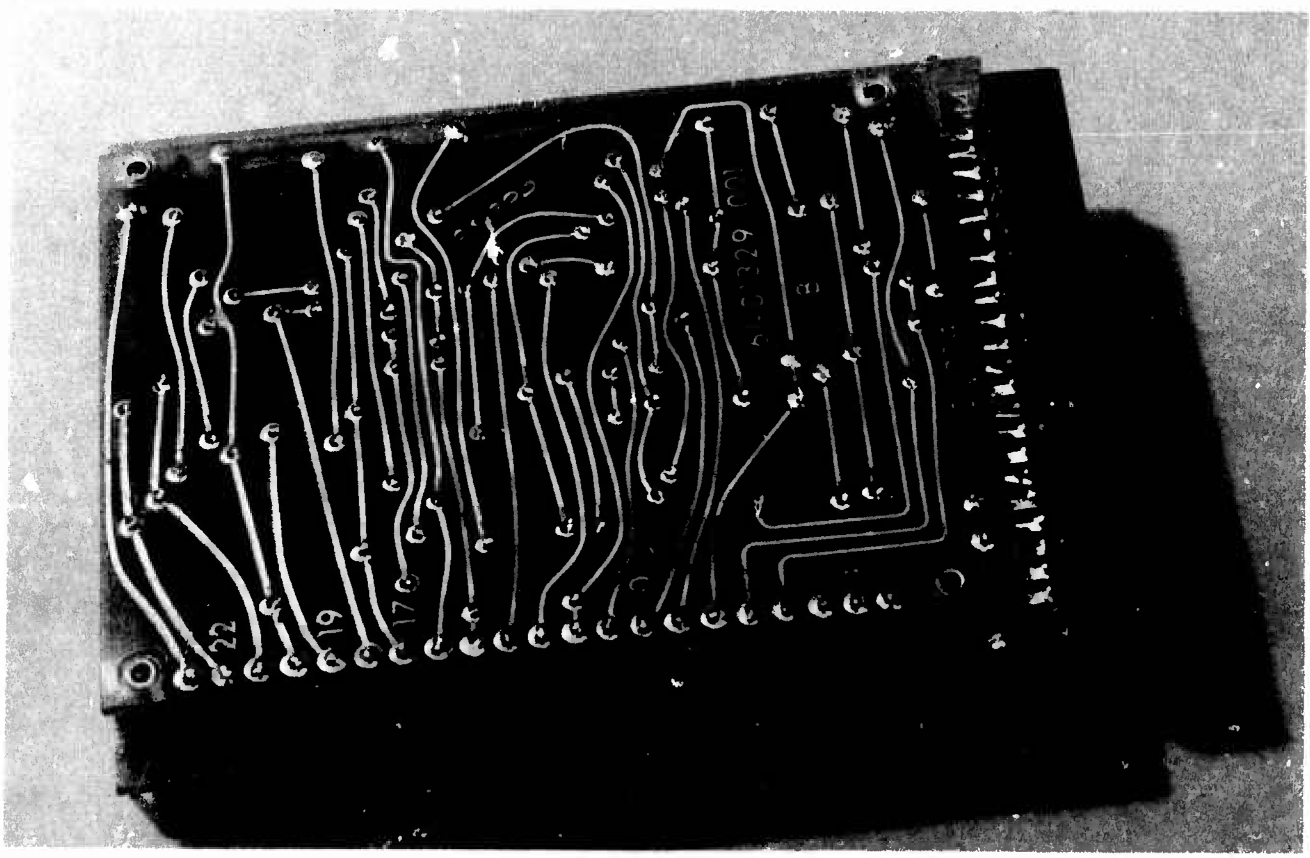


Figure 36. Logic PC Boards

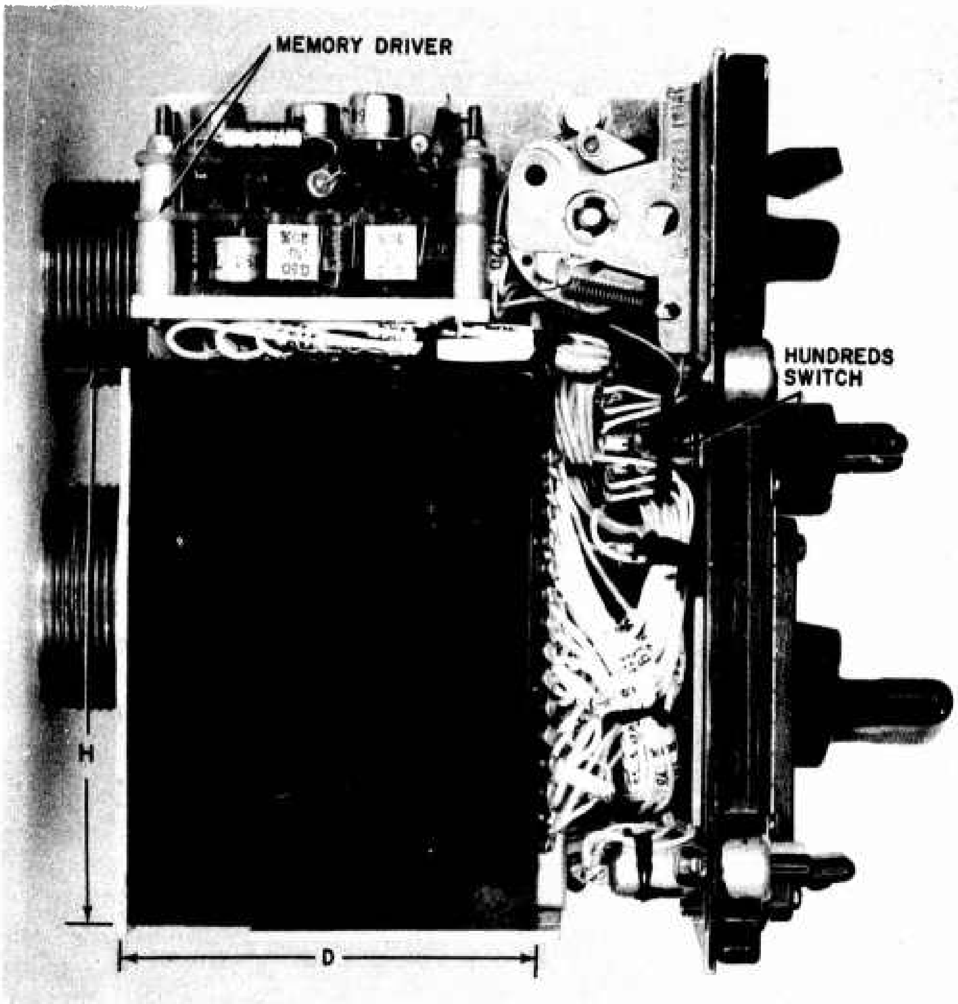


Figure 37. 50 kHz AN/ARC-145 Control Box, Left Side View

Using the basic electrical circuits and mechanical configuration of the 50 kHz AN/ARC-145 Control Box, a new Control Box was designed. Some of the improvements the new version offers are as follows:

- Simplified electrical design using fewer parts.
- Overvoltage protection of +5 VDC supply.
- Protection against improper clock sequencing during turn-on and turnoff.
- Protection of all input lines against line transients.

Figures 39 and 40 show the right and left side views of the 25 kHz AN/ARC-151 Control Box. Front views of the two versions shown in Figures 41 and 42 provide a good idea of the changes. Almost all the differences are associated with the frequency display. A mechanically-driven display is used on the newer design whereas the 50 kHz Control Box uses an electronically-driven frequency readout. Due to the space requirements, several of the controls were rearranged. The 50 kHz Control Box gives a "GO" indication by changing the frequency displayed to read "GO." On the 25 kHz Control Box, "GO" is displayed in a window just below the mode switch. Although there are some differences in the controls, both control boxes give the same capability and function with the exception of the number of channels.

The 25 kHz AN/ARC-145 Control Box and the AN/ARC-151 Control Box are almost identical. Only the front panel layout, the number of modes, and the number of diodes on one PC board are different. Figures 41 and 42 show the front view of the two boxes.

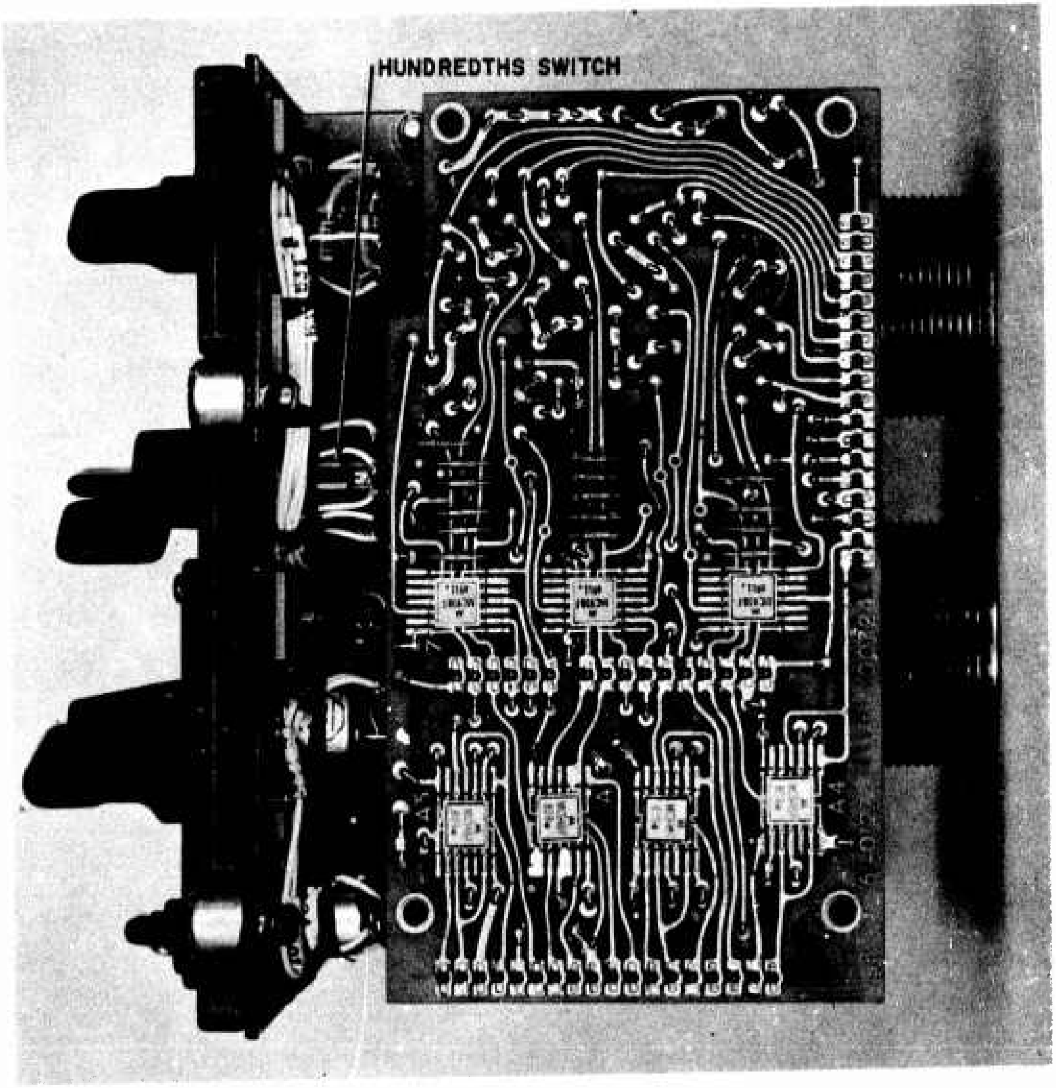


Figure 38. 50 kHz AN/ARC-145 Control Box, Right Side View

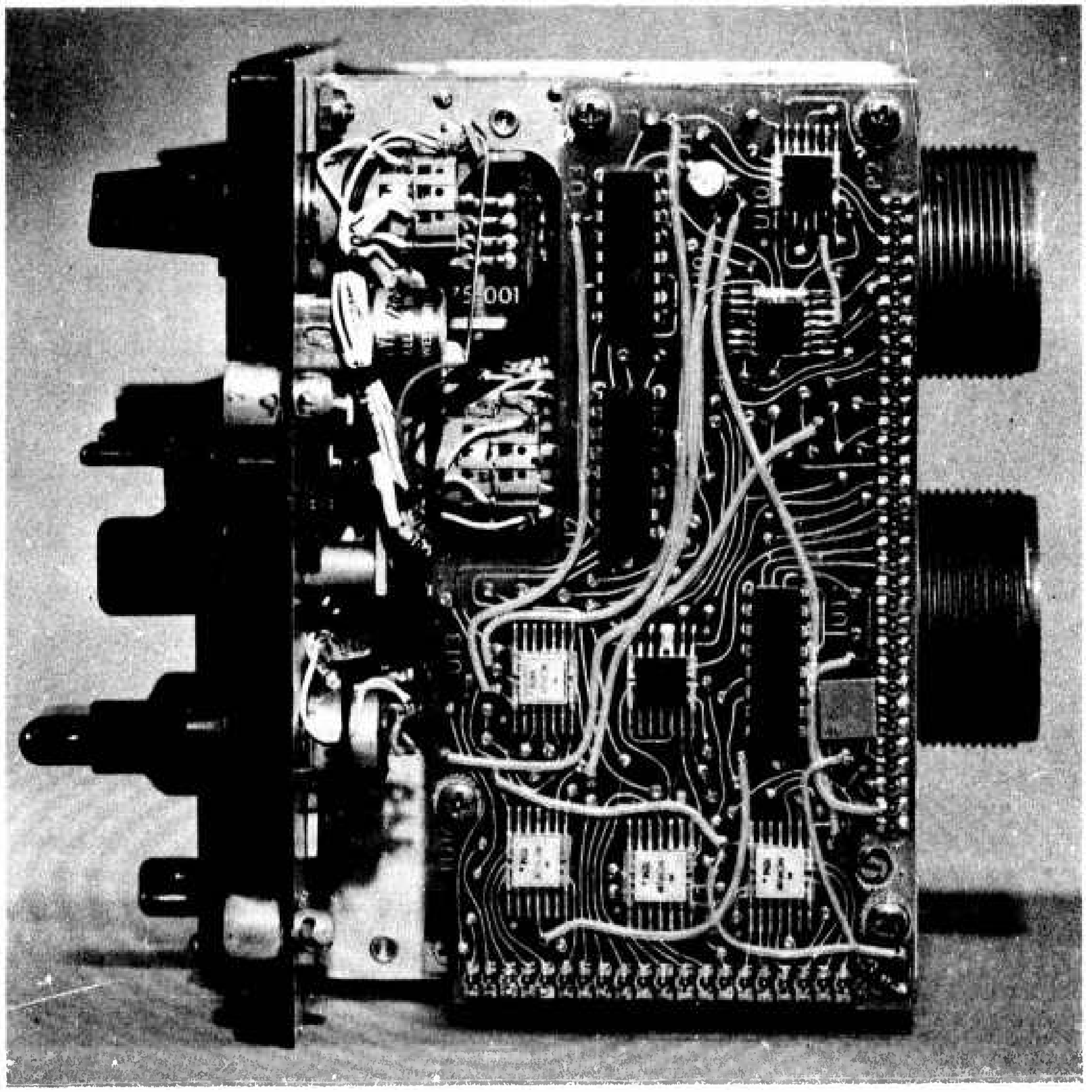


Figure 39. AN/ARC-151 Control Box, Right Side View

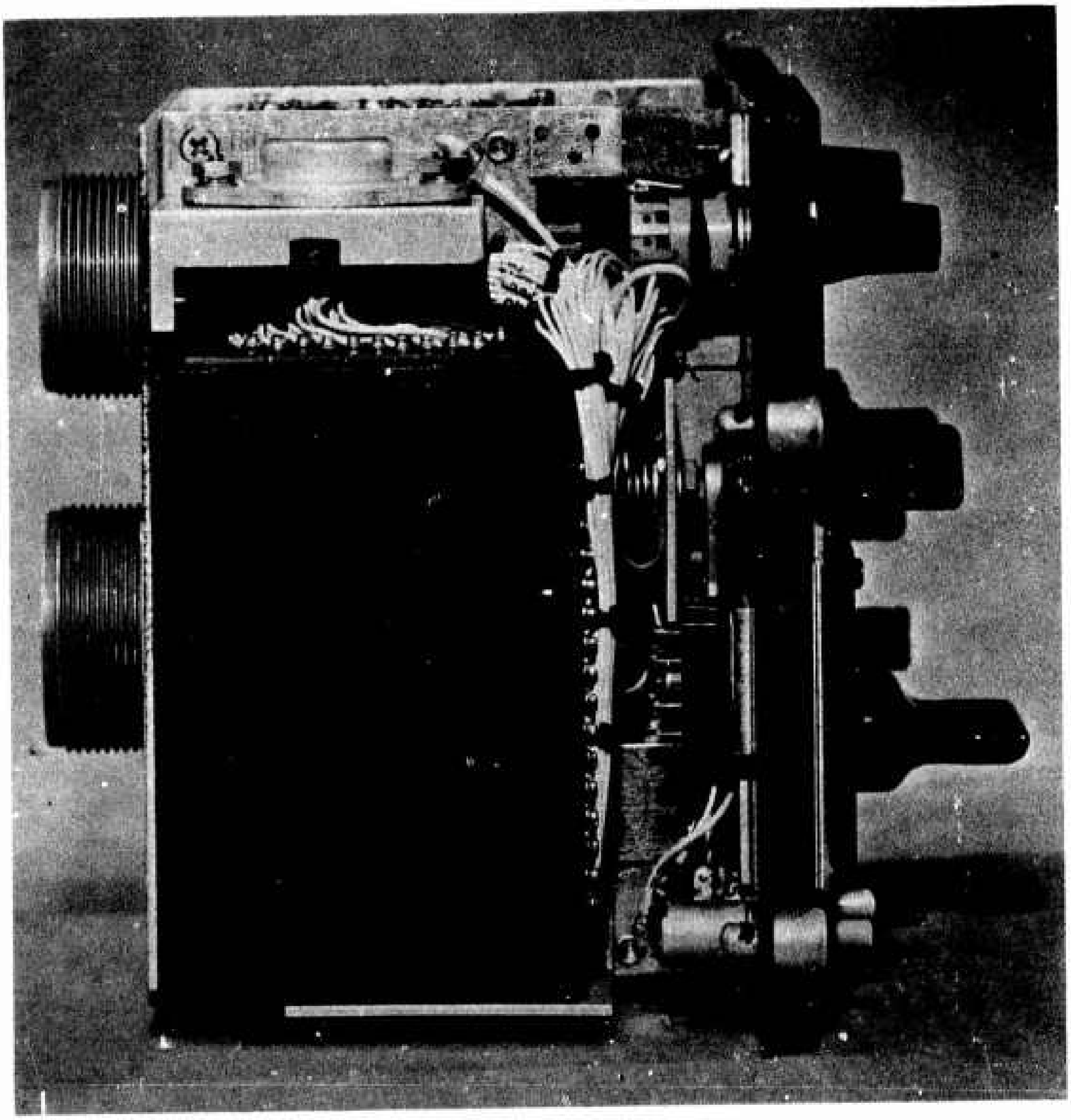


Figure 40. AN/ARC-151 Control Box, Left Side View

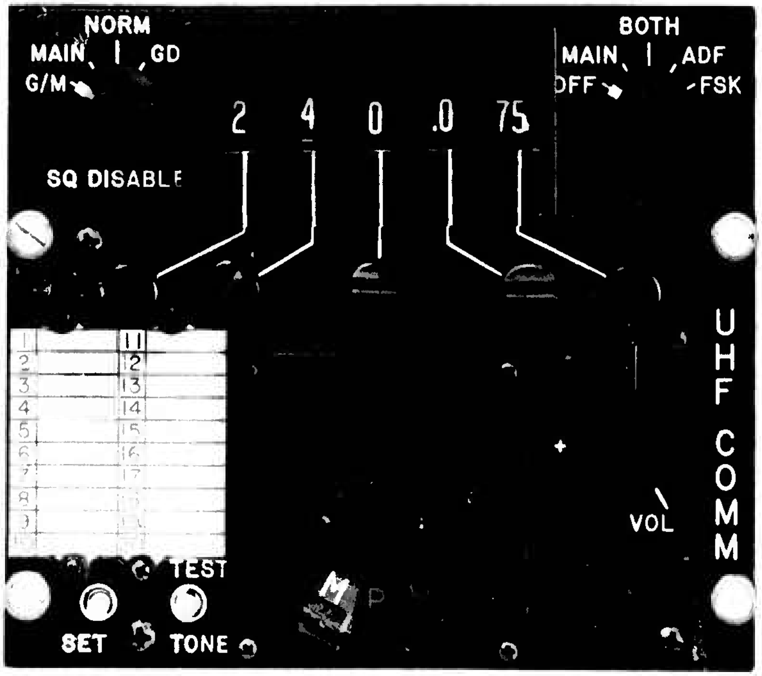


Figure 41. 25 kHz AN/ARC-145 Control Box, Front View

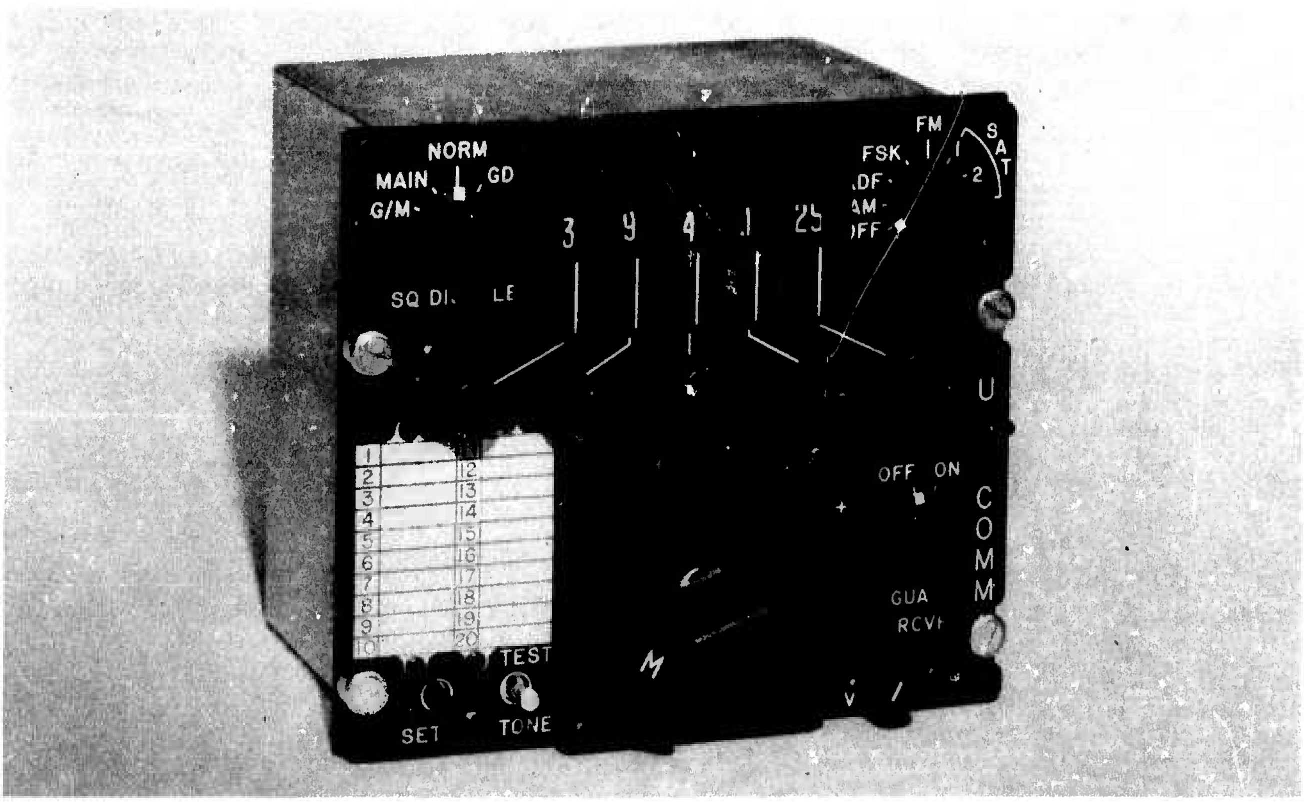


Figure 42. AN/ARC-151 Control Box, Front View

Figure 43. Remote Indicator

16. REMOTE INDICATOR

Modification to the Remote Indicator, shown in Figure 43, consists of relettering the least significant digit wheel and its associated electronic drive. Remote Indicator modifications also require the use of two additional leads from the Control Box to give 25 kHz channel information for Remote Indicator sensing. The new leads are not additional leads but are spare leads already existing in an aircraft wired for an AN/ARC-34 Radio Set.

17. PREAMPLIFIER ASSEMBLY

The purpose of the Preamplifier Assembly (Figure 44) is to lower the system noise figure for the Satellite Modes. Table VI gives the electrical characteristics of the assembly. With a receiver noise figure of 10 dB and 100 feet of cable between the Preamplifier and the Receiver, the worst case Preamplifier/Receiver noise figure will be 4.5 dB.

Table VI. Preamplifier Electrical Characteristics

Item	Characteristic
Input	50 ohm coaxial
Output	50 ohm coaxial
Amplifier gain	25 dB minimum
Amplifier noise figure	3 dB maximum
Filter bandpass	238 to 265 MHz
Filter insertion loss	1.0 dB maximum
Switching time	Less than 35 milliseconds

Table VI. Preamplifier Electrical Characteristics (Concluded)

Item	Characteristic
R/T interlock to preamp	"1" for SAT. Rx "0" for SAT. Tx and all other modes
R/T interlock from preamp	"1" or open for Tx inhibit "0" for OK to transmit

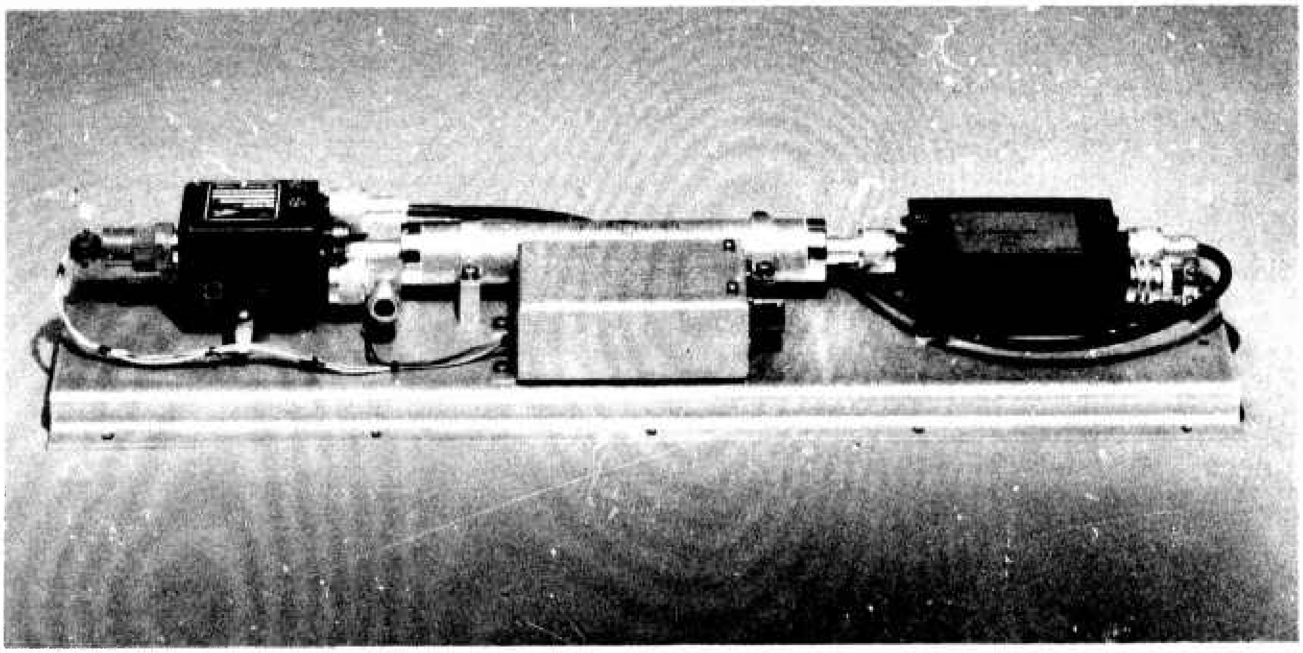


Figure 44. Preamplifier Assembly

SECTION III

75 BPS FSK MODIFICATION

1. GENERAL

Modification of the AN/ARC-151(V) (XA-1) to provide 75 bps FSK modulation capability required major changes to the Radio Set in some areas. The block diagram of the Radio Set with 75 bps FSK modulation is shown in Figure 45. Modified portions are indicated by shaded areas. Nomenclature for the modified Radio Set was changed from AN/ARC-151(V) (XA-1) to AN/ARC-151(V) (XA-2). Table VII gives a brief summary of the modifications.

All previous functions and capabilities of the AN/ARC-151(V) (XA-1) version were retained in the AN/ARC-151(V) (XA-2) configuration except the Link 4 FSK Mode. FSK Mode selection on the Control Box now selects 75 bps FSK modulation in place of Link 4 FSK modulation. In the AN/ARC-151(V) (XA-1), the Link 4 FSK Demodulator was part of the FM/FSK Detector. Since the FM/FSK Detector is also used for the FM Voice Mode, this module is still retained in the R/T Unit of the AN/ARC-151(V) (XA-1).

2. R/T CHASSIS

Chassis rework to accommodate the changes was accomplished without difficulty. Figure 46 shows the bottom of the Chassis and the location of the Front End Filter Select, the FSK Demodulator, and the 2nd Local Oscillator (L.O.). Figure 47 shows the Synthesizer modules extended from their location with the other modules of the Radio Set. The major portion of the Chassis modifications were incorporated into the Synthesizer and 2nd L.O. modules.

3. DATA CONVERTER

As discussed in the AN/ARC-151(V) (XA-1) Data Converter section, the Logic Interlock PC Board serves to control the R/T functions of the various Radio Set modules. The R/T Logic functions in the AN/ARC-151(V) (XA-2) were modified to the degree to warrant the redesign of the Logic Interlock PC Board. Basic overall operation of the (XA-2) Data Converter remains as in the AN/ARC-151(V) (XA-1). However, FSK Modulation (75 bps) can also be selected now by grounding a hardwire brought out to the control connector on the R/T Unit front panel.

4. FSK DEMODULATOR

As shown in the block diagram of the AN/ARC-151(V) (XA-2) configuration of the R/T Unit, the FSK Demodulator interfaces with the Receiver at the IF output. An 8.8 MHz signal is provided by the Main IF Amplifier. This interface was already in the wiring harness since it also supplies signals to the FM/FSK Detector and the AM Detector modules.

A block diagram of the FSK Demodulator is shown in Figure 48. The input 8.8 MHz signal to the FSK Demodulator is approximately -20 dBm. A Buffer Amplifier drives a Mixer which mixes an L.O. frequency of 8.345 MHz with the input 8.8 MHz to produce a 455 kHz IF signal. A Crystal Oscillator generates the 8.345 MHz conversion signal. The output of the Mixer is applied to a Mark/Space Crystal Filter through a matching IF Amplifier. The Mark/Space Filters have a 2 kHz bandpass and have center frequency separation of 5 kHz. Outputs of the filters are detected (envelope), filtered, and applied to a Data Comparator which provides a mark/space decision based on the channel with the most energy within the low pass filter bandwidth.

An AGC Amplifier is provided which controls the Main Receiver gain based on signal levels within these filter bandwidths. This AGC signal is applied directly to the AGC bus presently in the wiring harness. Isolation is provided by applying this AGC signal and the AM Detector AGC signal through biased diodes. The Data Converter mode control provides AGC selection and enable.

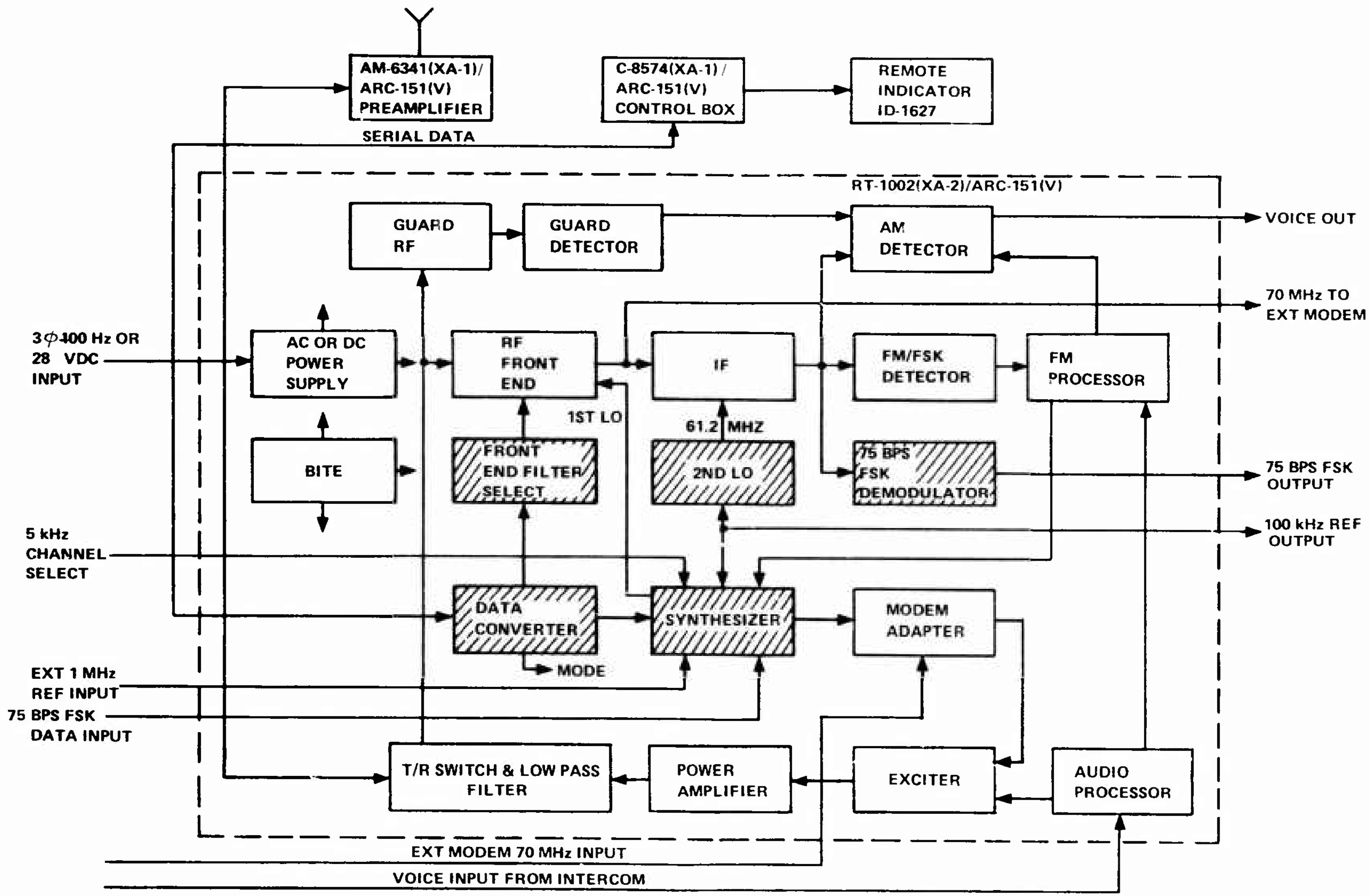


Figure 45. Radio Set AN/ARC-151(V) (XA-2) Block Diagram

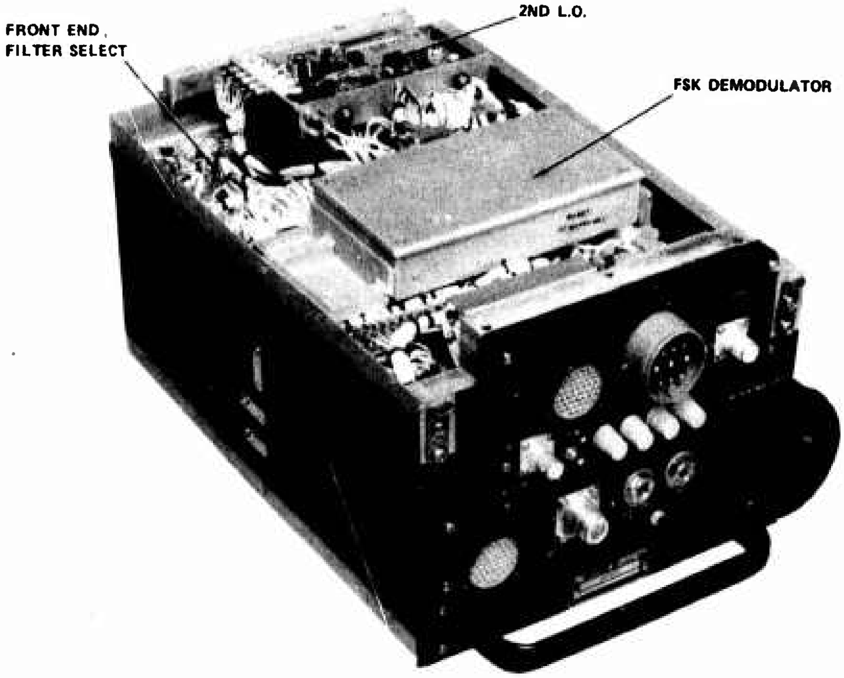


Figure 46. RT-1002 (XA-2)/ARC-151(V), Bottom View

A Threshold Detector is provided to squelch the data output when no signal is being received. This prevents the TTY equipment from printing undesired noisy signals. The FSK data output is a logic level, nominally 0 to +5 volts, single ended. When standard TTY drive is desired, an external level converter must be provided.

5. SYNTHESIZER

Operation of the AN/ARC-151(V) (XA-2) Synthesizer follows the same basic block diagram as was used in the AN/ARC-151(V) (XA-1) Synthesizer as shown in Figure 32. An AN/ARC-151(V) (XA-2) Synthesizer block diagram (Figure 49) does reveal a few differences. The (XA-2) Synthesizer injects a 100 kHz reference signal into the Phase Detector and also makes this reference signal available at the Radio Set front panel. By changing a jumper wire in the reference divider, the (XA-2) Synthesizer can be locked to an external 1 MHz reference. A one millisecond tuning time requirement imposed on the (XA-2) Synthesizer is met with the addition of a pretuned control. Selection of 5 kHz channels in the (XA-2) Synthesizer is accomplished similar to 25 kHz channel spacing selection. However, in 5 kHz channel spacing selection is not accomplished by the normal serial control. Instead the 5 kHz channel selection is fed into the Synthesizer on parallel lines available through the Radio Set Control connector.

Modifications to the Synthesizer design were necessary in the Programmed Divider, Phase Shifter Control, and VCO. Because so many circuits were affected, a complete repackaging effort was undertaken. By utilizing multifunction dual-in-line packages, an appreciable parts population savings was realized. Figure 50 shows the complete (XA-2) Synthesizer. All nine of the Synthesizer PC boards have components on one side only. A few boards can be considered densely populated.

Figure 51 shows the (XA-1) Synthesizer. As can be seen, several of the twelve PC boards are extremely crowded and have components on both sides.

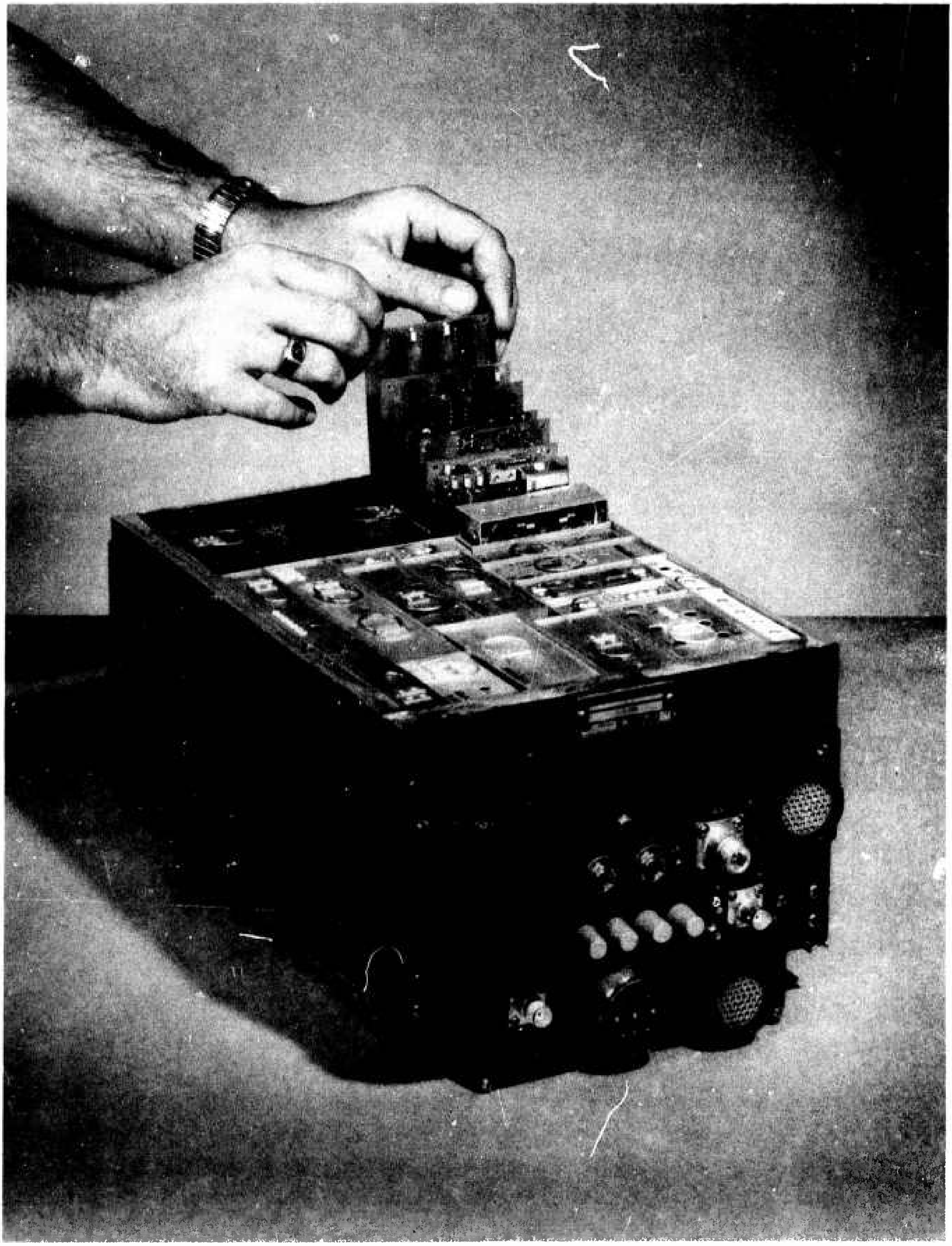


Figure 47. RT-1002 (XA-2)/ARC-151(V) With Synthesizer Card Extended

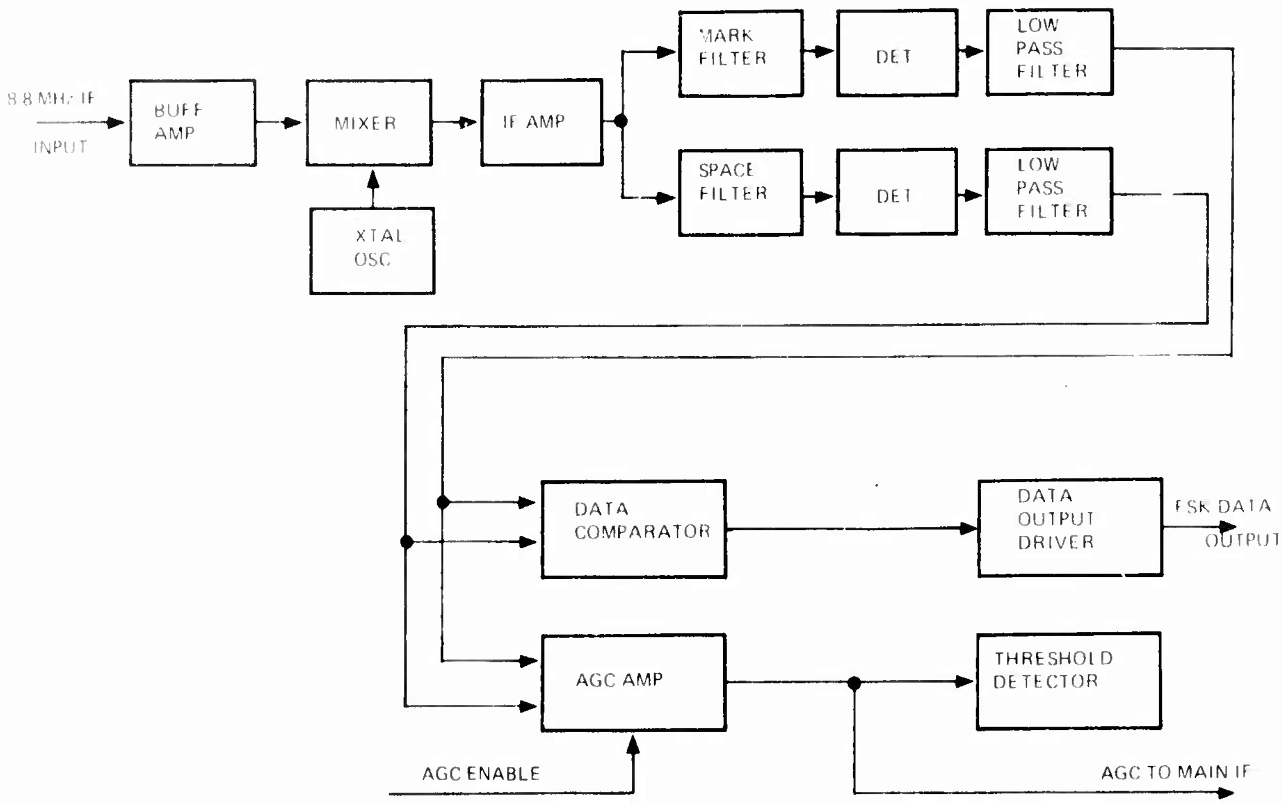


Figure 48. FSK Demodulator Module Block Diagram

Table VII. AN/ARC-151(V) (XA-2) Design Areas and Comparison To AN/ARC-151(V) (XA-1)

Component	Description Of Design Change and Comparison To (XA-1) Version
R/T Chassis	a. Wiring modified for new function
	b. Synthesizer area extensively modified for new synthesizer
	c. Added retainer brackets for FSK Demodulator
	d. Added 100 kHz output and 1 MHz input connectors to front panel
	e. Added compartment for 2nd L.O.
Data Converter	a. R/T Logic modified for new function
	b. Logic interlock PC board redesigned
FSK Demodulator	New module
Synthesizer	a. Major change to (XA-1) design
	b. All new PC boards
Front End Filter Select	a. Similar to function in (XA-1)
	b. New PC board
	c. Was in (XA-1) Synthesizer, now in chassis
2nd L.O.	a. Module taken from (XA-1) Synthesizer
	b. Modified and placed in chassis as separate module

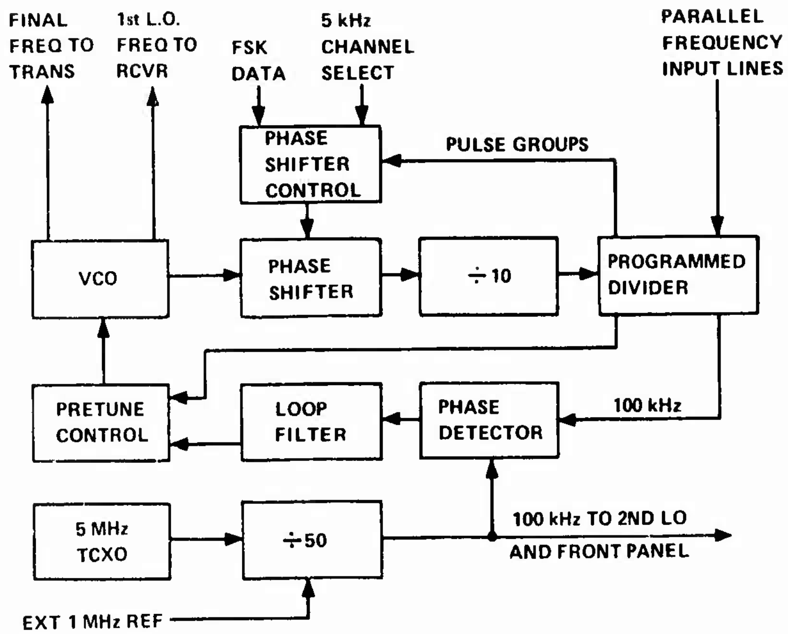


Figure 49. AN/ARC-151(V) (XA-2) Synthesizer Block Diagram

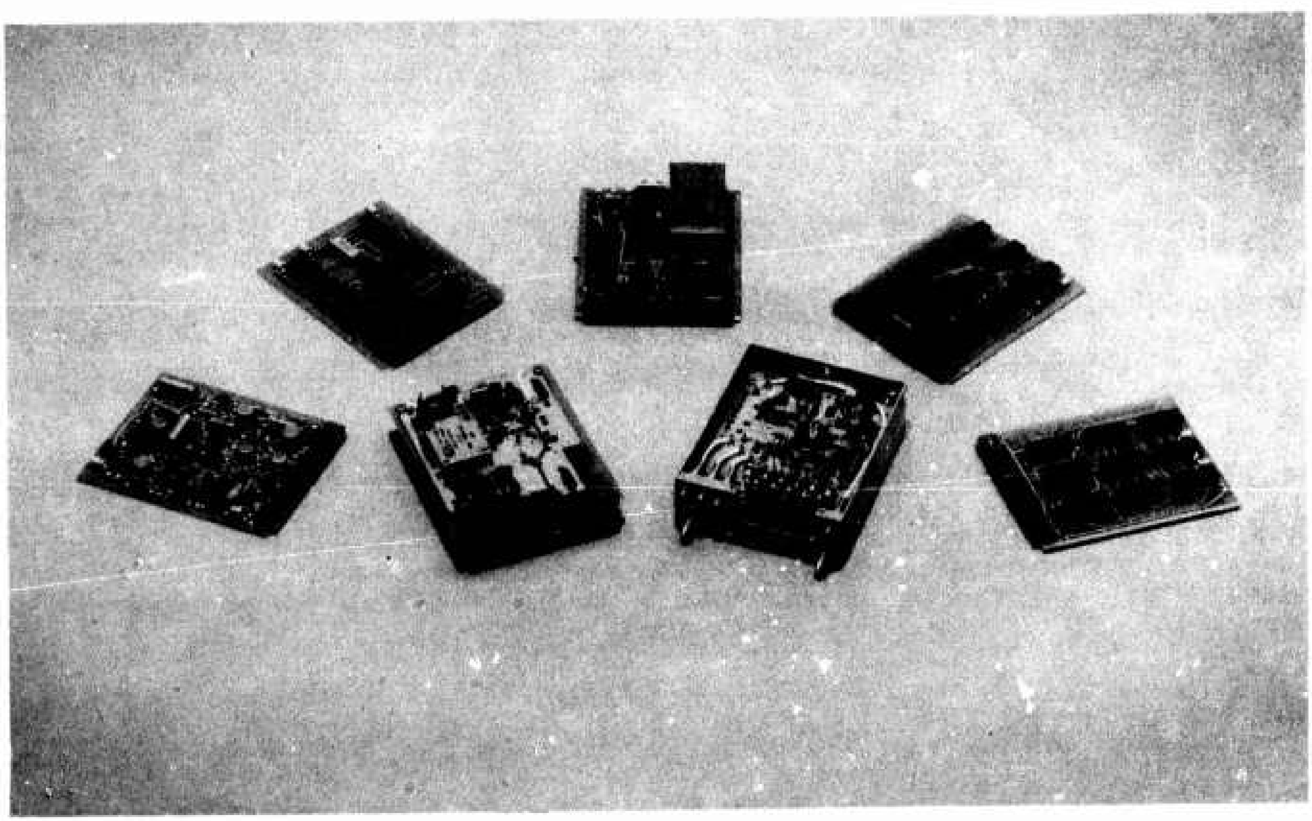


Figure 50. AN/ARC-151(V) (XA-2) Synthesizer

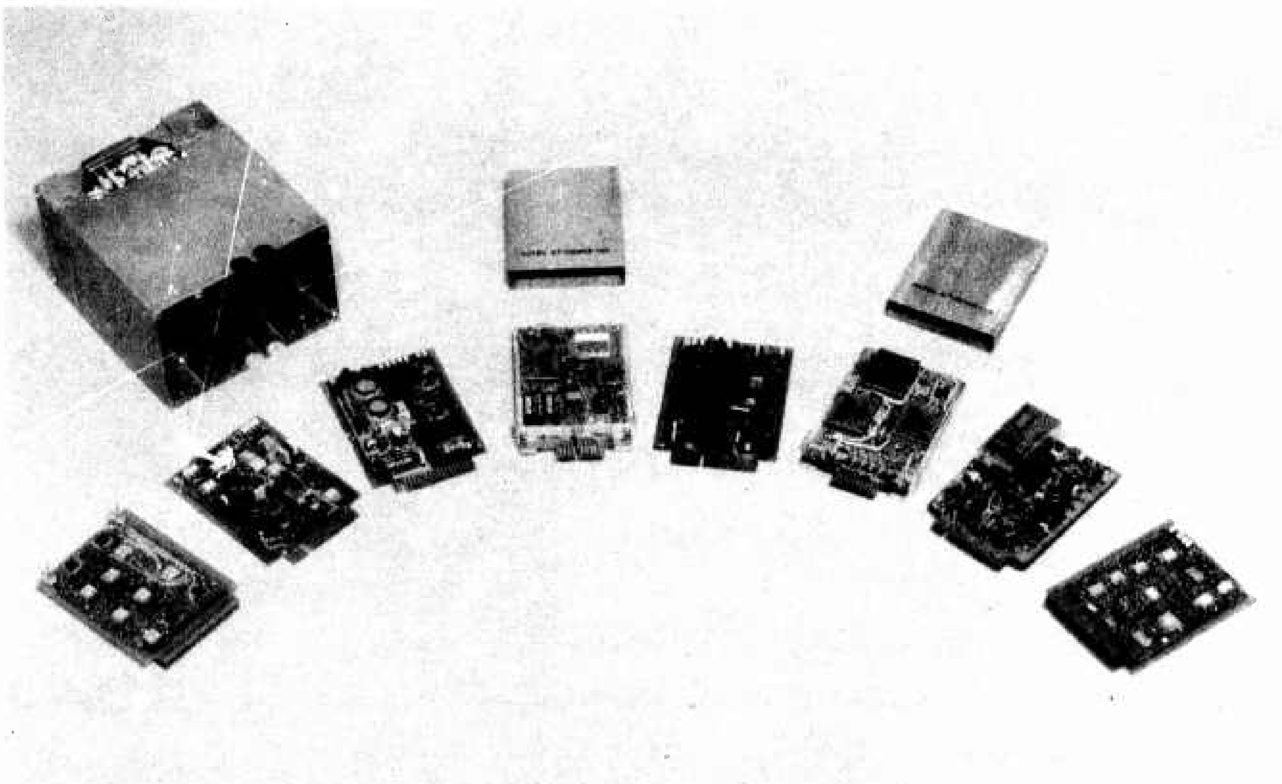


Figure 51. AN/ARC-151(V) (XA-1) Synthesizer

With the sophisticated modulation techniques being used in external modems, the level of IFM and phase jitter introduced by the Synthesizer is extremely critical. Potting of the (XA-2) Synthesizer VCO (see Figure 52) has contributed to its high resistance to mechanically induced phase jitter and FM.

6. FRONT END FILTER SELECT (FEFS)

The purpose of the FEFS circuit is to sample the frequency information between the Data Converter and the Synthesizer and to select the appropriate filter in the Receiver RF front end. In the AN/ARC-151 (V) (XA-1) this function was accomplished in the Synthesizer because the (XA-1) Synthesizer also had to select one of its own five output VC oscillators. However, in the (XA-2) Synthesizer, only two VC oscillators are used, and therefore, selection of the RF front end filter is no longer performed in the Synthesizer. Circuitry used in the FEFS is not complicated and chances of a failure are very remote. For this reason, the FEFS PC board is hardwired into the R/T Chassis and not easily removable.

7. 2nd LOCAL OSCILLATOR (2nd L. O.)

The 2nd L. O. for the (XA-1) Synthesizer was part of the Reference Generator and located with the other Synthesizer modules. Future Radio Sets will configure the 2nd L. O. as part of the IF Amplifier. In the (XA-2) AN/ARC-151, the 2nd L. O. was placed in the chassis as shown in Figure 32. Placing the 2nd L. O. in the chassis allows the (XA-1) and (XA-2) IF Amplifier modules to remain interchangeable. Also,not packaging the 2nd L. O. with the Synthesizer provides more room for the other Synthesizer boards. In addition, it allows the use, with modification, of the existing 2nd L. O.

Modifying an (XA-1) Reference Generator into an (XA-2) 2nd L. O. consisted mainly of removing parts and rerouting a few wires. Figure 53 compares the block diagrams of the two versions. The TCXO and divide-by-50 circuits for the (XA-2) Radio Set are still physically located in the Synthesizer.

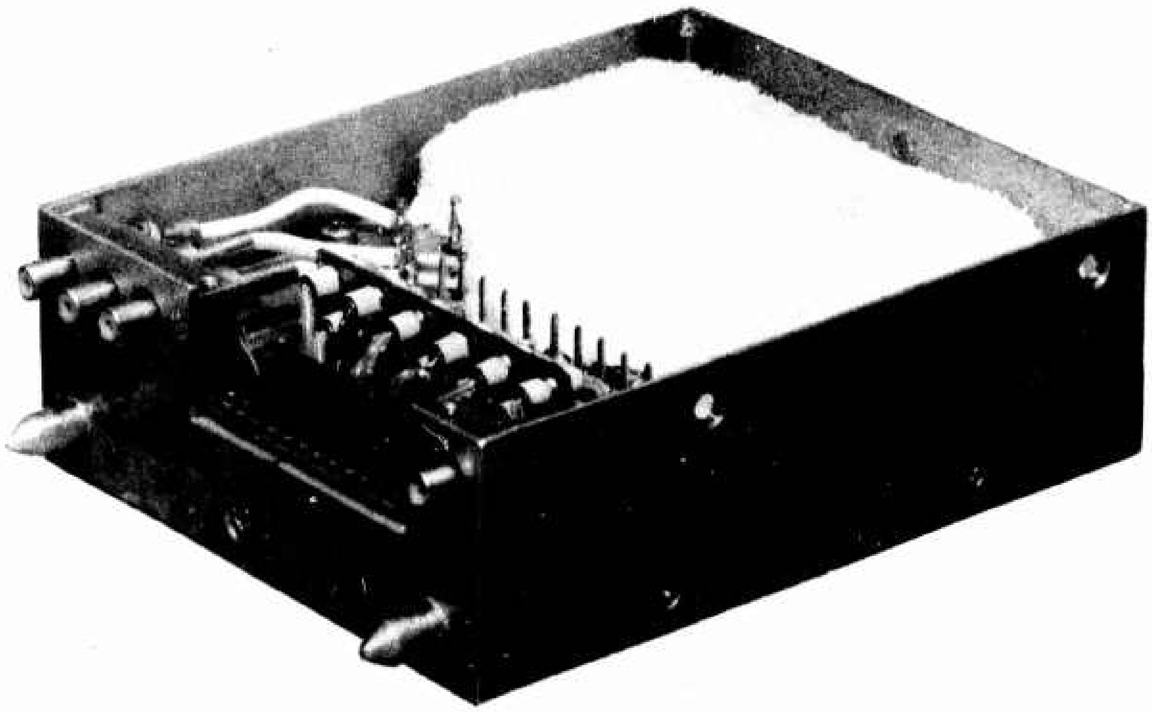


Figure 52. AN/ARC-151(V) (XA-2) Synthesizer VCO

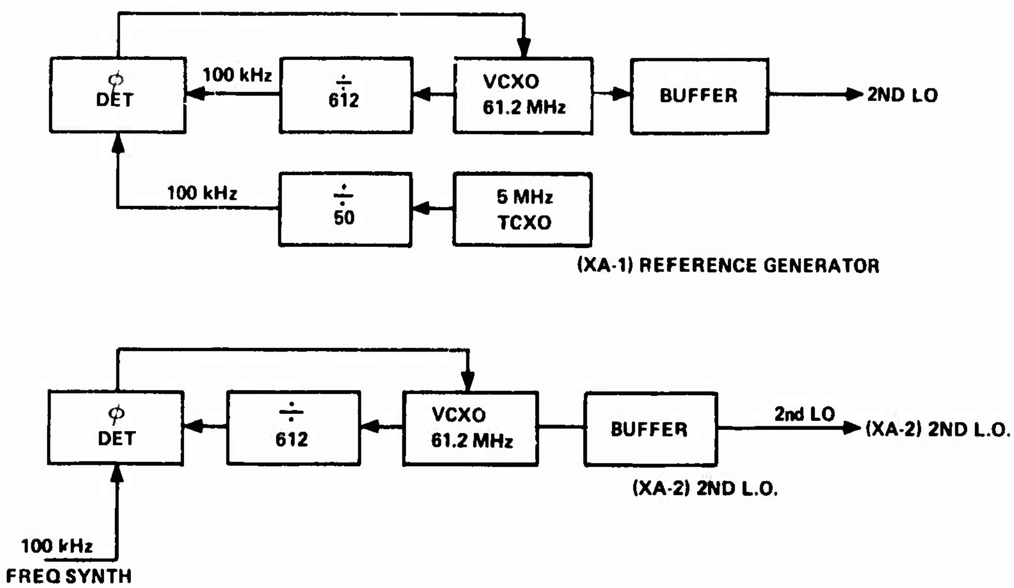


Figure 53. Comparison of (XA-1) and (XA-2) 2nd L. O.

SECTION IV

ENVIRONMENTAL AND ELECTROMAGNETIC INTERFERENCE (EMI) TESTS

1. ENVIRONMENTAL TESTING

Environmental testing of the AN/ARC-151 was limited to those tests which would satisfy safety of flight requirements and the power series tests. These tests were completed and the test limits met with a satisfactory margin. No conditions were found that would interfere with the flight testing program. Testing of the performance characteristics was conducted according to the Developmental Acceptance Test Procedure for Radio Set AN/ARC-151 (XA-1), ECI Document 58-01143-000, and the Environmental Test Procedure for Radio Set AN/ARC-151(V) (XA-1), ECI Document 58-01144-000.

Tests conducted to satisfy the safety of flight requirements are as follows:

- Explosion
- Vibration
- Selected Temperature/Altitude Tests

Shock testing was deleted because of similarity to the AN/ARC-145. Explosion testing of the AN/ARC-151(V) (XA-1) was completed successfully without problems of any kind. Figure 54 shows the R/T Unit in the explosion chamber. Vibration and temperature/altitude testing of the Amplifier-Filter Assembly, AM-6341(XA-1)/ARC-151(V), was carried out successfully without any difficulty. Vibration testing and temperature/altitude tests on the Control Box and R/T Unit were completed but with some difficulty.

Vibration testing of the R/T Unit in the major and minor horizontal axis was conducted without any problems to the structure of the unit. The R/T Unit, RT-1002(XA-1)/ARC-151(V), and mount is shown on the Vibration Table in Figure 55. However, several low frequency ($\leq$ 110 Hz) mechanically induced FM electrical resonances were noted during the major and minor horizontal R/T Unit vibration testing. During resonant dwells on these frequencies, receiver S/N was degraded. When a 300 Hz high-pass filter was placed in series with the receiver output, the S/N was well within specification limits. Because no danger to an aircraft can be caused by the mechanically induced FM, this problem was not resolved during testing of the AN/ARC-151(V) (XA-1). Later vibration testing performed on the AN/ARC-151(V) (XA-2), in which the Synthesizer VCO is potted, found no mechanically induced incidental FM frequency degradation.

Vibration testing in the vertical axis of the R/T Unit found the shock tray appearing to flex an unacceptable amount. This condition only occurred at the resonant frequency ($\simeq$ 20 Hz) of the shock mounts. With only 10 minutes remaining out of two hours resonant frequency dwell, the vertical axis testing was stopped and the mounting tray examined. The only sign of fatigue was a small ($\simeq$ 1/8 inch long) crack found in one corner of the mounting tray. Figure 56 shows the mounting tray with the cracked corner. Even though the vibration test could most likely have been completed without a catastrophic tray failure, the tray was at best marginal. A stiffening member was incorporated into the tray design as shown in Figure 57. Later vertical axis vibration testing with the RT-1002(XA-2)/ARC-151(V) on a stiffened mounting tray gave no indication of the flexing problem experienced previously.

Vibration testing of the Control Box in the major horizontal axis was completed without any electrical or mechanical problems during the test. Unfortunately, when the Control Box was examined following the test, an internal bracket was found broken at a 90° bend. Figure 58 shows the Control Box with the broken bracket. A new bracket with a more uniform and stronger bend was made. Figure 59 shows the new bracket installed. Since the Control Box did not appear to be a hazard to flight testing, all remaining Control Box Vibration Testing was deleted.

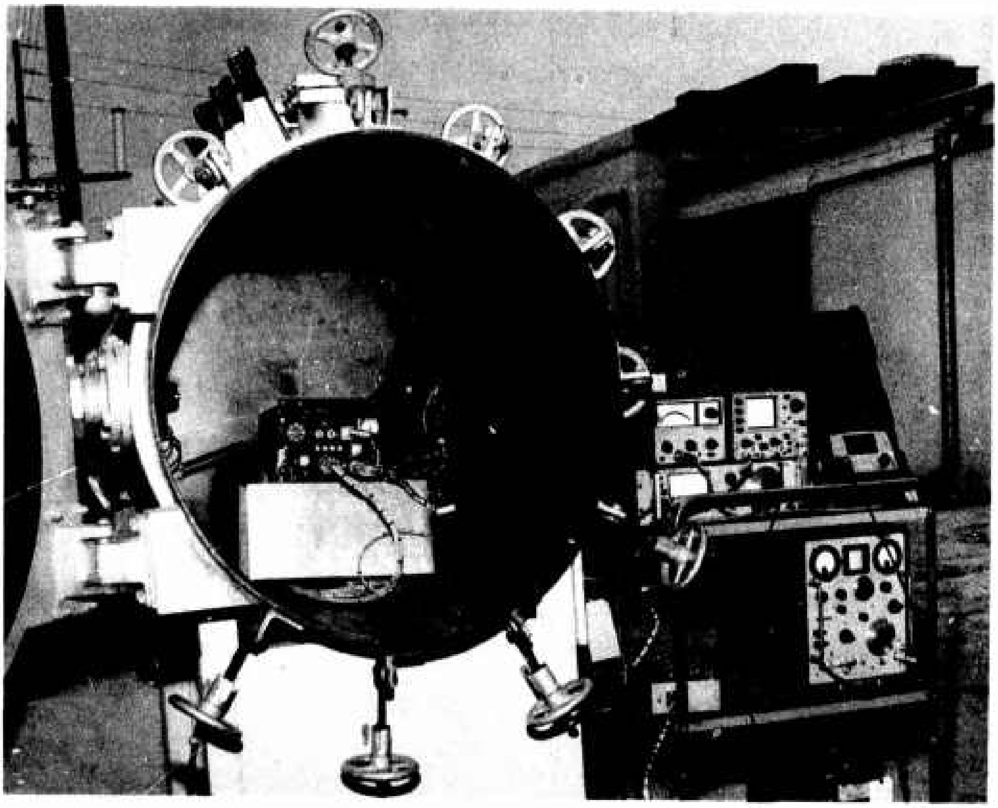


Figure 54. RT-1002(XA-1)/ARC-151(V) In Explosion Chamber

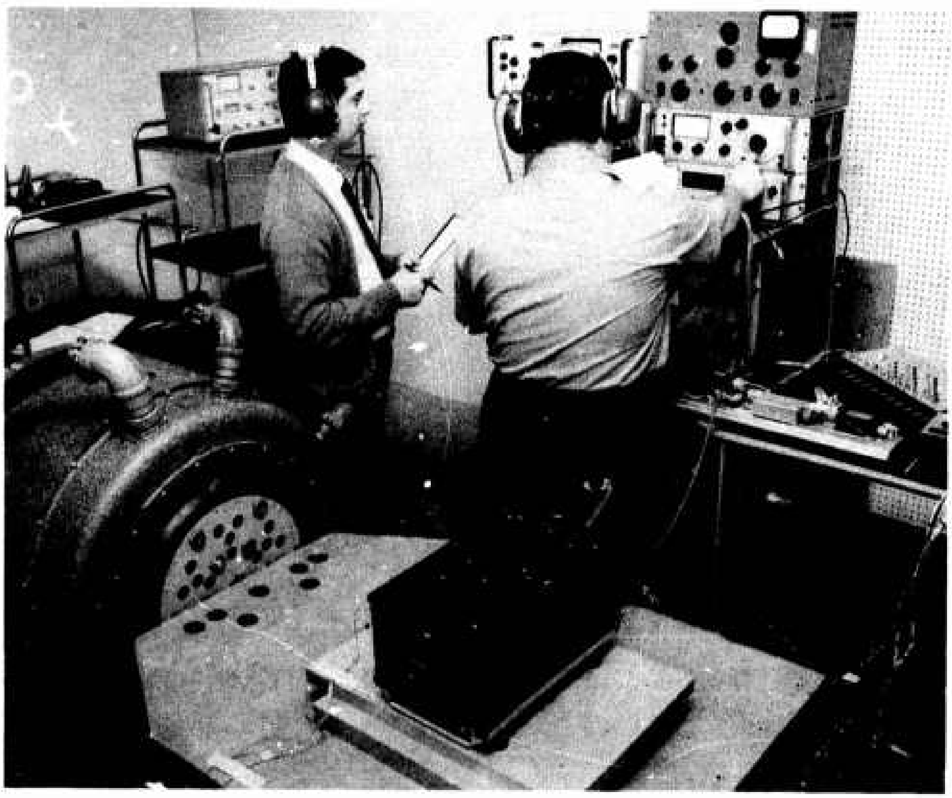


Figure 55. RT-1002(XA-1)/ARC-151(V) During Minor Horizontal Axis Vibration Test

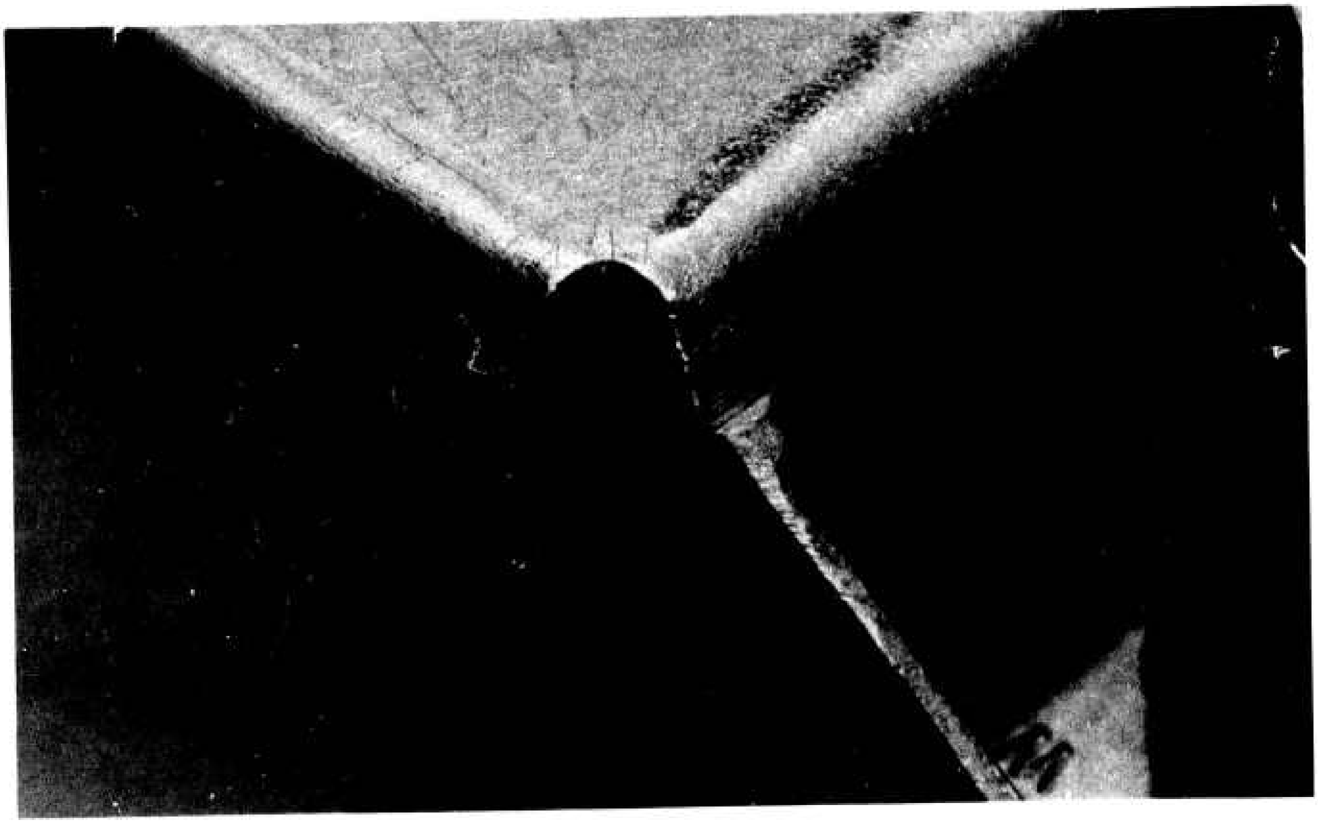


Figure 56. Mounting Tray After Vertical Axis Vibration Test

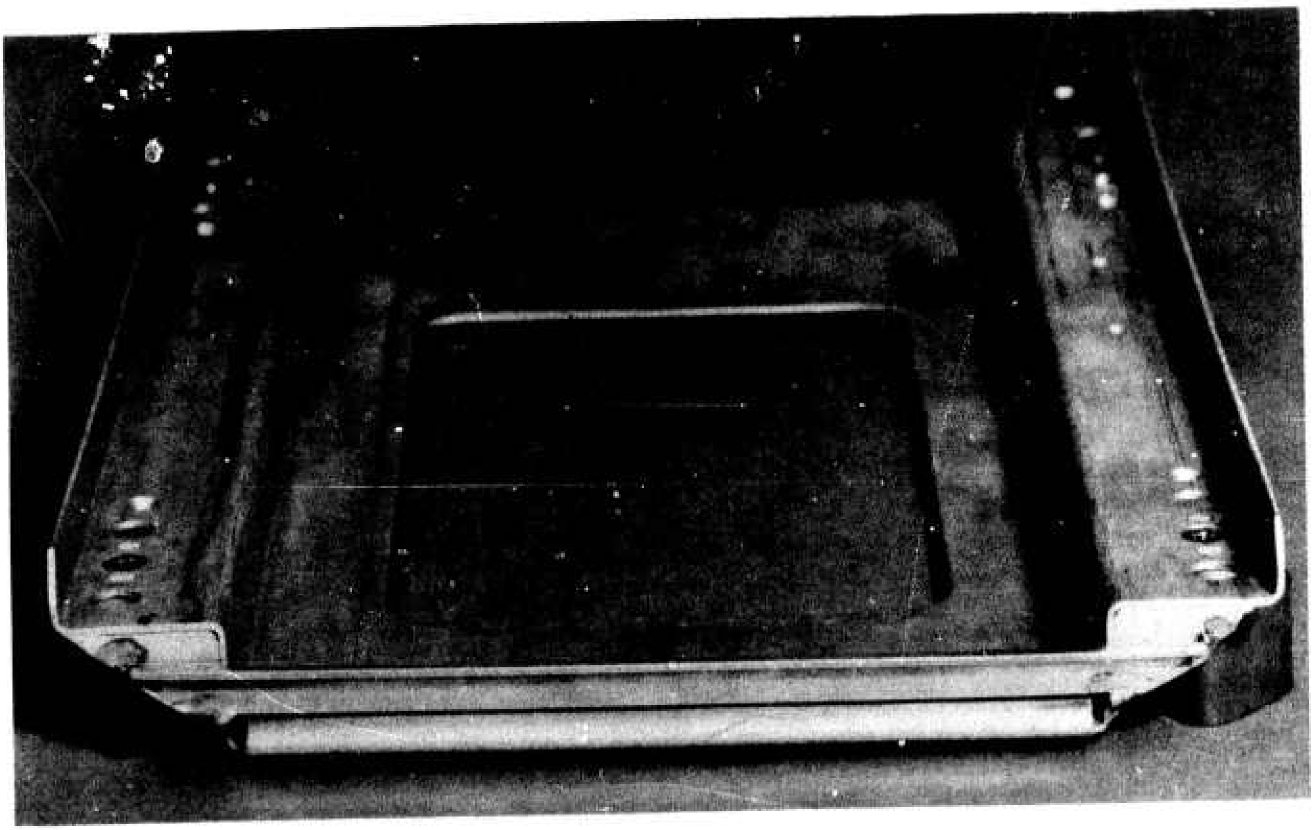


Figure 57. Mounting Tray With Stiffening Member Added

Figure 58. Control Box After Major Horizontal Axis Vibration Test

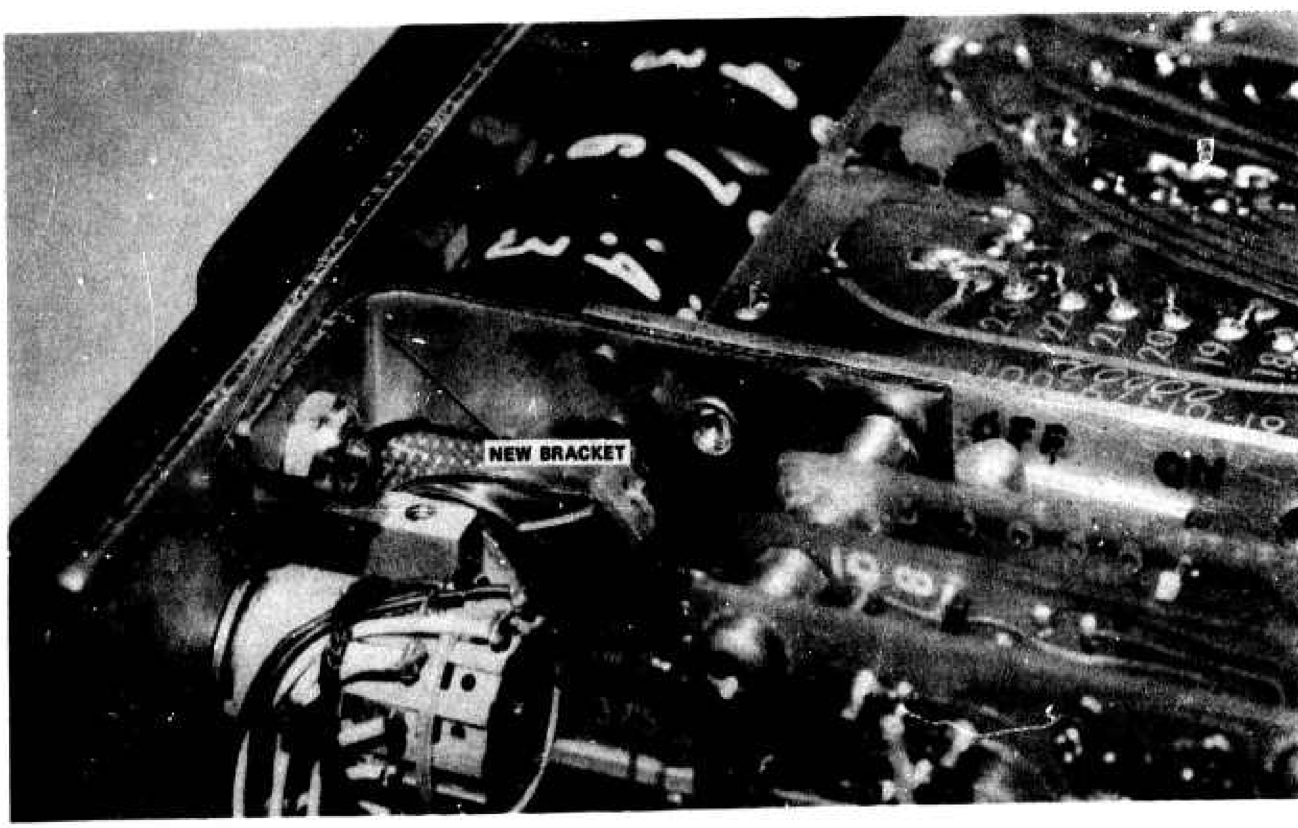


Figure 59. Control Box With Modified Bracket

Performing step two (-54°C at sea level) of the temperature-altitude series was successful except for a few problem areas. The 5V power supply and 64 kHz clock in the Control Box exhibited excessive temperature coefficients. Temperature compensation was incorporated into both circuits. Additional testing of the Control Box proved good. At some frequencies in FM the Main Receiver sensitivity did not meet specification and the FM squelch would not close. The Transmitter operated successfully early in the test but would not key during subsequent tests. Proper operation of the R/T Unit was restored as the temperature was raised. R/T Unit problems were not completely resolved, but the Data Converter was most likely the cause. Temperature compensation was added to the Data Converter "one" detector because of troubles experienced in this circuit in later tests.

During step 6 (71°C and sea level) the shift register integrated circuits in the Data Converter became excessively hot and failed to operate properly. A heat sink was added to the Data Converter as shown in Figure 60. Subsequent tests for step 9 (36°C and 50,000 feet) which produce equivalent internal temperatures were successful. Testing for step 5 (95°C) was also successful.

Power series tests were performed with the AC Power Supply and RT-1002(XA-2)/ARC-151(V). All of the tests were accomplished within the specification limits and without equipment difficulties.

2. ELECTROMAGNETIC INTERFERENCE TESTING

Electromagnetic Interference tests were performed on the AN/ARC-151(V) (XA-1) during March, April, and May, 1971. Tests were conducted in accordance with the AN/ARC-145 EMI Test Procedure, ECI Document 58-00941-000. As an aid to reduce the amount of data taken and expedite testing, all emission signals greater than 10 dB below the specified limits were not recorded. Generally, when a test fails at one operating frequency, the test also fails at the other test frequencies. Therefore, test data was taken only at one operating frequency when test data was not within specification limits. When within specification limits, data was taken at three operating frequencies. All tests were run using the AC Power Supply. Testing with the DC Power Supply was deleted.

Table VIII provides a summary of the EMI Test results.

Table VIII. EMI Test Results

Test	Acceptable or Within Spec	Out of Spec at Some Frequencies
Conducted Interference		X
Radiated Interference		X
AF Conducted Susceptibility	X	
RF Conducted Susceptibility	X	
RF Radiated Susceptibility	X	
Antenna Conducted Key Up		X
Antenna Conducted Key Down		X
Intermodulation	X	
Front End Rejection	X	

Conducted and radiated interference tests were out of specification limits due to the interconnecting cable between the Radio Set and Control Box. The basic contributor to the out of specification signals was the serial data stream twisted pair. Data on these leads consists of a pulse width modulated 8 kHz signal. Rise and fall times of the signal are only a few microseconds. If adequate filtering was used on the data stream leads, the information would be unrecoverable at the Radio Set. However, by carefully

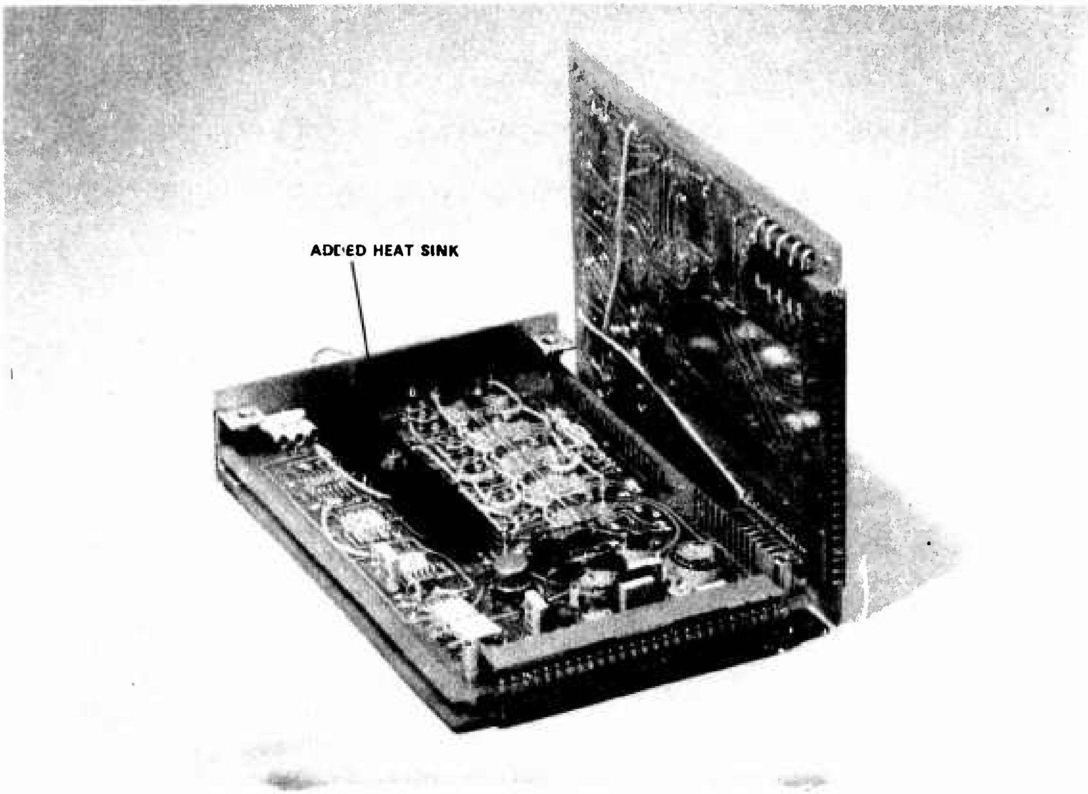


Figure 60. Data Converter With Heat Sink Added To Shift Register Integrated Circuits

rerouting the related grounds in the Control Box, the test results were lowered from 13 dB out of specification limits to within 5 dB of the specification limits. The test was only rerun for one test condition but results should improve for all.

Antenna conducted key up also was out of specification limits due to the low frequency signals generated by the serial data stream. There was an additional problem caused from the Guard Receiver local oscillator (107 MHz) for both the antenna conducted key up and key down tests. Filtering has been added to the Guard Receiver local oscillator circuitry which materially reduced interference caused by it.

SECTION V

MAINTAINABILITY PREDICTION FOR AN/ARC-151 RADIO SET

1. SCOPE

This Maintainability Prediction report has been prepared to provide an estimate of the corrective maintenance time to be anticipated in the support of the AN/ARC-151 Radio Set. This prediction is based on the December 1969 Maintainability prediction for the AN/ARC-145 Radio Set, the latest reliability estimate, and the current design information.

2. REFERENCED DOCUMENTS

The following documents were utilized in the preparation of this prediction for indicated purposes.

• MIL-HDBK-472 (Procedure III)	Maintainability Prediction
• Statement of Work for UHF Command/ Satellite Transceiver	Maintainability Requirements
• ECI Engineering Data	Maintainability Task Analysis
• ECI Maintainability Prediction for AN/ ARC-145 dated Dec. 1969	Maintenance Times

3. MAINTENANCE CONCEPT

This Maintainability Prediction is based on the following maintenance concept.

a. Organizational Maintenance

(1) Flight-Line (Airplane Level) Maintenance

Flight-line maintenance is that maintenance performed at the aircraft and consists of fault detection of a malfunction in the Radio Set, fault isolation of a malfunction to a Line Replaceable Unit (LRU), removal and replacement of the malfunctioned LRU, and functional testing of the Radio Set to verify operational status. The fault detection, fault isolation, and functional test requirements are limited to the use of the Built-in-Test features of the Radio Set. Maintenance at this level is supported with spare LRU's from the Organizational Shop level of maintenance.

(2) Organization Shop Maintenance

Organizational Shop Maintenance is that maintenance performed in the Organizational Maintenance facility and consists of providing operational spare LRU's to support Flight-Line maintenance. Maintenance at this level is accomplished through the use of the Bench Test Set which provides a system and LRU checkout capability. Organizational Maintenance is supported with spare LRU's, technical manuals, and adequate training for AFSC 3 and 5 level personnel.

b. Field Maintenance

Field Maintenance is that maintenance performed at a designated central facility to support several Organizational Maintenance facilities. It consists of fault detection, fault isolation to a plug-in module, removal and replacement of the malfunctioned module, and functional testing of the LRU to

verify operational status. The fault detection, fault isolation, and functional test requirements are accomplished through the use of the Bench Test Set. Maintenance at this level is supported with spare plug-in modules, technical manuals, the Bench Test Set and associated standard test equipment, and adequate training for AFSC 3 and 5 level personnel. Malfunctioned modules are either discarded or sent to depot for repair.

c. Depot Maintenance

Depot maintenance is that maintenance performed at a higher level maintenance facility and consists of all maintenance not performed at the Organizational and Field Maintenance levels. Maintenance is performed to the piece part or non-repairable level by highly skilled personnel utilizing both common and special test equipment. Depot level maintenance is supported with spare piece parts, technical manuals, common and special test equipment, and specialized training.

4. BENCH TEST SET

The Bench Test Set required by the above maintenance concept is assumed, for the purposes of this prediction, to be a modified version of the AN/ARM-140 (XA-1). The modifications would include the following functional changes to facilitate the AN/ARC-151 Radio Set.

- The power handling capability of the dummy load must be increased to 100 watts.
- The test set control capability must be modified so that the mode select logic format is compatible with the AN/ARC-151.
- Interface hardware must be fabricated to accommodate the ARC-151 connectors.
- The module "self-check" function must be modified to permit isolation of problems to the two additional modules in the ARC-151.

5. DEFINITIONS

The following terms and sumbols, as defined below, will be used in the calculations for this prediction.

• $\overline{M}_{ct}$	Mean corrective maintenance time
• M_{maxct}	Maximum corrective maintenance time
• $\overline{Mpt}$	Mean prevention maintenance time
• N	Sample size
• Ø	Confidence level
• K	Accuracy of prediction
• σ	Population standard deviation
• $\log M_{ct}$	Common logarithm of corrective maintenance time
• $\overline{\log M_{ct}}$	Mean of $\log M_{ct}$
• $\sigma \log M_{ct}$	Mean log of M_{ct} Standard Deviation

6. MAINTAINABILITY REQUIREMENTS

The AN/ARC-151 maintainability requirements, as defined in the statement of work, are described below.

a. Organizational Level

The Radio Set shall possess a Mean Corrective Maintenance time ($\bar{M}_{ct}$) of no greater than five minutes, a Mean Preventive Maintenance time ($\bar{M}_{pt}$) of no greater than five minutes, and a Maximum Corrective Maintenance time (M_{maxct}) of no greater than 10 minutes at the 90th percentile.

b. Field Level

The Radio Set shall possess a Mean Corrective Maintenance time ($\bar{M}_{ct}$) of no greater than 45 minutes, a Mean Preventive Maintenance time ($\bar{M}_{pt}$) of no greater than 15 minutes, and a Maximum Corrective Maintenance time (M_{maxct}) of no greater than 60 minutes at the 90th percentile.

7. MAINTAINABILITY PREDICTION

This maintainability prediction is based on the techniques presentation given in MIL-HDBK-472, procedure III. The actual procedure has been modified to permit substitution of maintenance time data from the AN/ARC-145 estimate. The new data is also based on similarity and engineering judgment rather than the maintenance analyses checklists and nomograph of the referenced document. The various steps and calculations are described in the following paragraphs.

a. Sample Size

In consideration of the low sample sizes calculated previously for the AN/ARC-145, and the minimum task size of 50 for a valid sample, a minimum sample size (N) of 50 will be used.

b. Task Selection

The tasks for this prediction have been limited to corrective maintenance because no preventive maintenance is anticipated. Tasks have been further limited to the intermediate level of maintenance in view of the simplicity of the Organization Maintenance action.

(1) Apportionment to Module Level

The tasks are apportioned to the module level of the Radio Set on a percent of failure rate basis. The failure rates of the modules are converted to percentages of the total Radio Set failure rate and the results correlated to a sample size of 50. The numbers are then rounded off to the nearest whole number to establish the task distribution. The apportionment results in 51 tasks as presented in Table IX.

(2) Task Assignments, Analysis, and Estimates

Inasmuch as the AN/ARC-151 design is very similar to the AN/ARC-145 design with those differences at the module level insignificant as far as maintenance times are concerned, the tasks apportioned above are correlated to the task apportionment and selection of the AN/ARC-145 maintainability prediction. The mean maintenance times at the module level have been retained for the common modules and new times have been estimated for the peculiar modules, based on experience in the laboratory and similarity of design to the other modules as well as engineering judgment and analyses utilizing schematics, block diagrams, engineering data, and maintainability features of the design considerations. The basic time estimates are presented in Table X and the task assignments with their expanded data presented in Table XI.

c. Data Analysis

The maintenance times are calculated from the following equations of MIL-HDBK-472, procedure III.

(1) Mean Corrective Maintenance Time ($\overline{M}ct$)

The calculation of $\overline{M}ct$ is:

$$\overline{M}_{ct} = \frac{\sum_{i=1}^{i=N} Mct_i}{N} = \frac{1483}{51} = 29.08 \text{ minutes}$$

(2) Maximum Corrective Maintenance Time (M_{MAXct})

The calculation of M_{MAXct} at the 90th percentile is:

$$M_{MAX_{ct}} = \text{antilog} \left[\overline{\log M_{ct}} + 1.645 \; \sigma_{\log Mct} \right]$$

$$\text{where } \overline{\log M_{ct}} = \frac{\sum_{i=1}^{i=N} \log Mct_i}{N}$$

$$\text{and } \sigma_{\log Mct} = \sqrt{\frac{\sum_{i=1}^{i=N} (\log Mct_i)^2 - \frac{\left(\sum_{i=1}^{i=N} \log Mct_i\right)^2}{N}}{N-1}}$$

$$\text{then } M_{MAXct} = \text{antilog} \left[\frac{74.7371}{51} + 1.645 \sqrt{\frac{109.9836 - \frac{(74.7371)^2}{51}}{50}} \right]$$

$$= \text{antilog} \left[1.4654 + 1.645 \sqrt{.009227} \right]$$

$$= \text{antilog} \left[1.4654 + .1580 \right]$$

$$= \text{antilog} \; 1.6234$$

$$M_{MAXct} = 42.15 \text{ minutes}$$

(3) Verification of Task Sample Size

The same size of 51 is seen to be adequate from the task size equation for minimum size as follows:

$$N \left[\frac{\phi \, \sigma}{K \, \overline{M}_{ct}} \right]^2 \quad \text{where } \phi = 1.282 \text{ for } 90\% \text{ confidence}, \; K = .1 \text{ for } 90\% \text{ accuracy}$$

$$\text{and } \sigma = \sqrt{\frac{\sum_{i=1}^{N} (Mct_i)^2 - \frac{\left(\sum_{i=1}^{N} Mct_i\right)^2}{N}}{N-1}}$$

$$= \sqrt{\frac{46849 - \frac{(1483)^2}{51}}{50}}$$

$$= \sqrt{74.514}$$

$$= 8.632$$

then

$$N \left[\frac{1.282 \times 8.632}{.1 \times 29.08}\right]^2 = 14.48$$

which is much less than 50.

8. CONCLUSIONS

The predicted maintenance times indicate that the quantitative maintainability requirements of the procurement specifications have been attained in the AN/ARC-151 Radio Set. The specified times at the flight line will be readily achieved through the Built-in-Test and quick disconnect features of the design. Test and checkout times are in the order of seconds while removal and replacement may be accomplished in a couple of minutes. The specified times at the field maintenance level may also be readily achieved through the use of a Bench Test Set. There is no planned or preventive maintenance anticipated. The mean corrective maintenance time estimated of 29 minutes is well below the specified value of 45 minutes, and the calculated maximum corrective maintenance time of 42 minutes is below the specified value of 60 minutes.

Table IX. AN/ARC-151 Malfunction Distribution and Task Apportionment

ITEM	Failure Rate Per 10^5 Hours λ	Percent Contribution of Total λ	Number of Tasks for N=50	Number of Tasks Allocated
RCVR-XMTR RADIO				
A1 Case, Rcvr.-Xmtr Radio	1.4674394	4.88	2.44	2
A2 Amplifier RF	2.2649374	3.45	1.73	2
A3 Ampl. Assy IPA/PA	3.3778557	5.15	2.58	3
A3 Ampl. Assy Exciter	2.0226650	3.08	1.54	2
A5 Switch, Antenna	0.4449017	.68	.34	0
A6 Test Set, Radio BITE	0.4888191	1.87	.93	1
A7 Detector, Freq. Shift	0.2799618	.43	.22	0
A8 Amplifier, IF	2.9672622	4.52	2.26	2
A9 Power Supply AC	4.6429786	5.36	2.68	3
A10 Synth. Elec. Freq.	10.9425888	21.22	10.61	11
A11 Rcvr Guard	4.2174081	8.18	4.09	4
A12 Rcvr Guard Det.	3.7754645	5.75	2.87	3
A13 Detector AM	2.4204268	3.69	1.84	2
A14 Data Converter	5.6780843	11.01	5.51	6
A15 Audio Processor	2.2864112	2.64	1.32	1
A16 FM Processor	3.3181033	6.43	3.22	3
A17 Modem Adapter	0.2785663	.42	.21	0
	50.8738742	88.75	44.39	45
CONTROL, RADIO SET	8.4799385	9.79	4.88	5
PRE-AMPLIFIER FILTER	1.2638618	1.46	.73	1
Totals	60.6176745	100.00	50.00	51

Table X. AN/ARC-151 Intermediate Maintenance

UNIT	DESCRIPTION	P/.	MTTR Hr.	MTTR Minutes
	RCVR-XMTR, RADIO	01-00916-001		
A1	CASE, RCVR-XMTR-RADIO	03-02594-001	.72	43
A2	AMPLIFIER RF	03-02040-001	.55	33
A3	AMPLIFIER ASSY IPA/PA	03-02595-001	.50	30
A4	AMPLIFIER ASSY EXCITER	03-02094-001	.62	37
A5	SWITCH, ANTENNA	03-02717-001	.33	20
A6	TEST SET, RADIO BITE	03-02256-001	.38	23
A7	DETECTOR, FREQ. SHIFT	61-01017-001	.33	20
A8	AMPLIFIER IF	03-02247-001	.52	31
A9	POWER SUPPLY AC	03-02598-001	.48	29
A10	SYNTH. ELECTRICAL FREQ.	03-02661-001	.58	35
A11	RCVR, GUARD	03-02076-001	.55	33
A12	RCVR, GUARD DETECTOR	03-02308-001	.55	33
A13	DETECTOR, AM	03-02727-001	.38	23
A14	DATA CONVERTER	03-02597-001	.40	24
A15	AUDIO PROCESSOR	61-01344-001	.35	21
A16	FM PROCESSOR	03-02600-001	.42	25
A17	MODEM ADAPTOR	03-02601-001	.33	20
	CONTROL, RADIO SET	01-00917-001	.25	15
	PRE-AMPLIFIER FILTER	01-00918-001	.25	15

Table XI. Maintenance Time Summary

Task No.	ITEM	Mct_i Minutes	$(Mct_i)^2$	LogMcti	$(\text{Log}M_{cti})^2$
1	A1 Case, Rcvr-Xmtr.	43	1849	1.6335	2.6683
2	A1 Case, Rcvr-Xmtr.	41	1681	1.6128	2.6011
3	A2 Ampl. RF	31	961	1.4914	2.2243
4	A2 Ampl. RF	34	1156	1.5315	2.3455
5	A3 Ampl. Assy. IPA/PA	30	900	1.4771	2.1818
6	A3 Ampl. Assy. IPA/PA	31	961	1.4914	2.2243
7	A3 Ampl. Assy. IPA/PA	30	900	1.4771	2.1818
8	A4 Ampl. Assy Exciter	37	1369	1.5682	2.4593
9	A4 Ampl. Assy Exciter	37	1369	1.5682	2.4593
10	A6 Test Set BITE	23	529	1.3617	1.8542
11	A8 Ampl. IF	31	961	1.4914	2.2243
12	A8 Ampl. IF	31	961	1.4914	2.2243
13	A9 Power Supply AC	28	784	1.4472	2.0944
14	A9 Power Supply AC	29	841	1.4624	2.1386
15	A9 Power Supply AC	30	900	1.4771	2.1818
16	A10 Synthesizer	28	784	1.4472	2.0944
17	A10 Synthesizer	31	961	1.4914	2.2243
18	A10 Synthesizer	32	1024	1.5051	2.2653
19	A10 Synthesizer	31	961	1.4914	2.2243
20	A10 Synthesizer	31	961	1.4914	2.2243
21	A10 Synthesizer	31	961	1.4914	2.2243
22	A10 Synthesizer	56	3136	1.7482	3.0562
23	A10 Synthesizer	31	961	1.4914	2.2243
24	A10 Synthesizer	31	961	1.4914	2.2243
25	A10 Synthesizer	56	3136	1.7482	3.0562
26	A10 Synthesizer	30	900	1.4771	2.1818
27	A11 Receiver, Guard	30	900	1.4771	2.1818
28	A11 Receiver, Guard	36	1296	1.5563	2.4221
29	A11 Receiver, Guard	30	900	1.4771	2.1818
30	A11 Receiver, Guard	37	1369	1.5682	2.4593
		1007	35333	45.5353	69.3080

Table XI. Maintenance Time Summary (Concluded)

Task No.	ITEM	Mct_i Minutes	$(Mct_i)^2$	LogMcti	$(LogM_{cti})^2$
31	A12 Receiver Guard Det.	34	1156	1.5315	2.3455
32	A12 Receiver Guard Det.	34	1156	1.5315	2.3455
33	A12 Receiver Guard Det.	32	1024	1.5051	2.2653
34	A13 Detector AM	23	529	1.3617	1.8542
35	A13 Detector AM	23	529	1.3617	1.8542
36	A14 Data Converter	24	576	1.3802	1.9050
37	A14 Data Converter	24	576	1.3802	1.9050
38	A14 Data Converter	24	576	1.3802	1.9050
39	A14 Data Converter	24	576	1.3802	1.9050
40	A14 Data Converter	24	576	1.3802	1.9050
41	A14 Data Converter	24	576	1.3802	1.9050
42	A15 Audio Processor	21	441	1.3222	1 7482
43	A16 Audio Processor	25	625	1.3979	1.9541
44	A16 Audio Processor	25	625	1.3979	1.9541
45	A16 Audio Processor	25	625	1.3979	1.9541
46	Control Radio Set	15	225	1.3522	1.8284
47	Control Radio Set	15	225	1.3522	1.8284
48	Control Radio Set	15	225	1.3522	1.8284
49	Control Radio Set	15	225	1.3522	1.8284
50	Control Radio Set	15	225	1.3522	1.8284
51	PRE-AMPLIFIER FILTER	15	225	1.3522	1.8284
		476	11516	29.2018	40.6756
		1483	46849	74.7371	109.9836

SECTION VI

RELIABILITY ANALYSIS UHF COMMAND/SATELLITE TRANSCEIVER

1. ABSTRACT

This final reliability report presents the results of the reliability analyses performed for AFAL under Contract No. F 33615-69-C-1818.

The purpose of these analyses is to predict the Reliability of the AN/ARC-151 UHF Command Satellite Transceiver expressed as Mean Time Between Failures (MTBF). The MTBF requirements specified in the statement-of-work are as follows:

- Predicted minimum acceptable MTBF - no less than 1600 hours
- Predicted Design Goal MTBF - 2000 hours

The analyses contained herein demonstrate compliance with the specified requirements.

2. REFERENCED DOCUMENTS

AFAL

- Exhibit A — Statement of Work
- Contract F33615-69-C-1818 — UHF Command/Satellite Transceiver 12 May 1969

AFSC

- DH 1-5 — AFSC Design Handbook DH-1

RADC

- PB 161894 — RADC Reliability Notebook, Volume II, TR-67-108

3. REQUIREMENTS

The Reliability requirements for the UHF Command/Satellite Transceiver AN/ARC-151, as contained in paragraphs 3.4.4.2.2 and 3.4.4.2.3 of the statement-of-work, Exhibit A to Contract F33615-C-1818, are stated as follows:

- RELIABILITY DESIGN REQUIREMENTS (3.4.4.2.2). The RADC Reliability Notebook Volume II shall be used as the guideline for the "Reliability Prediction" and the data shall be submitted as a part of the R&D Contract Status Report as required.

- SPECIFIC RELIABILITY REQUIREMENTS (3.4.4.2.3). The Radio Set shall possess a predicted mean time between failure (MTBF) of no less than 1600 hours (minimum acceptable MTBF) with a design goal of 2000 hours MTBF. For purposes of determining MTBF, the Preamplifier shall not be included.

a. Cooling Air

Both self contained blower cooling and provisions for adaptation to external forced air cooling are specified. The specified thermal profile with self contained cooling covers the range of -54°C to +71°C and with external forced air cooling covers the range of -54°C to 50°C. The operational temperature with self-contained cooling is considered to be 55°C; 40°C when operated with external forced air cooling. These values represent the average operating temperature within the equipment during a normal mission.

b. Equipment Description

The AN/ARC-151(V) (XA-1) Radio Set consists of the following:

- Receiver-Transmitter Unit - including the blower assembly, RT-1002 (XA-1)/ARC-151(V)
- Control Box, C-8574 (XA-1)A
- Preamplifier, AM-6341 (XA-1)

The reliability analysis of the Preamplifier is not required by specification; however, the results of ECI's analysis are given in Table XII.

4. ANALYSIS

a. Reliability Block Diagram

In developing the reliability block diagram, the equipment was considered to be structured of functionally identifiable modules containing one or more assemblies or subassemblies. Further, the failure of any operational part within the module, would, in some way, degrade the operation of the module which in turn would result in unsatisfactory performance of the equipment. These considerations permit the use of the simple series string model shown in Figure 61.

b. Mathematical Model

In order to reduce the mathematical model to its most practical form, each module was considered to be independent. Specific parts within the module are energized for the appropriate intervals determined by the Transmit-Receive duty cycle. This approach selectively applies the duty cycle weighting factors to the failure ratio of only those parts within each module that see cyclical changes in stress level. No weighting is considered for those parts that are unaffected by the duty cycle. This method results in a lower MTBF than that obtained by applying duty cycle weighting at the assembly or module level. This method also provides a better appraisal of the expected reliability when the equipment is operated under maximum traffic conditons. In addition, this method simplifies the mathematical model to the form shown in Figure 61.

c. Assumptions and Consideration

(1) Temperature Stress Levels

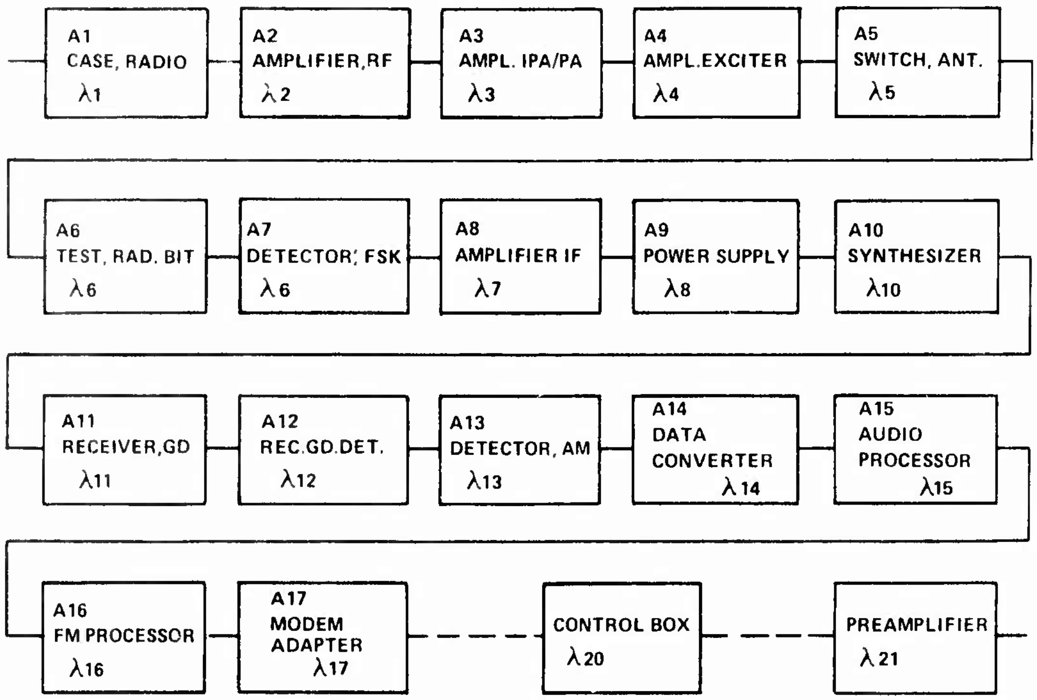
The AFSC Design Handbook DH-1, Design Notes DN2A3 and DN1C1, were consulted for the basic information used to estimate average mission operational temperatures. The temperature stress was assumed to be uniform throughout the equipment.

(a) Self Contained Cooling Mode

The average part temperature for a typical mission is estimated to be 55°C. Average cooling air temperature is 40°C.

Table XII. Reliability Analysis Radio Set AN/ARC-151

MOD. IDENT.	MODULE DESCRIPTION	PARTS	FAILURE RATE %/1000 HRS
A1	Case, Rec-Trans, Radio	108	1.467437
A2	Amplifier, RF	214	2.264916
A3	Amplifier, IPA/PA	282	3.377828
A4	Amplifier, Exciter	214	2.022651
A5	Switch, Antenna	87	.444900
A6	Test, Radio BIT	164	.488819
A7	Detector, FSK	51	.279961
A8	Amplifier, IF	169	2.967240
A9	Power Supply, AC	239	4.642966
A10	Synthesizer, Elec, Freq.	435	10.942359
A11	Receiver, Guard	174	4.216068
A12	Receiver, Guard Detector	215	3.775446
A13	Detector, AM	211	2.420421
A14	Data Converter	98	5.678073
A15	Audio Processor	117	2.286411
A16	FM Processor	139	3.318093
A17	Modem Adapter	111	.278566
	Total	3028	50.872148
	RT Unit MTBF		1965.71
	Control Box, Radio Set	174	8.479887
	Total RT & CB	3202	59.352035
	Radio Set MTBF		1684.86
	Pre-Amplifier	26	1.263861
	Total RT, CB & Pre Amp	3228	60.615896
	Total Equip MTBF		1649.73



FAILURE RATE RT UNIT

$\lambda_{RT} = \lambda_1 + \lambda_2 + \ldots\ldots \lambda_{17}$

FAILURE RATE RT & CONTROL BOX

$\lambda_{RS} = \lambda_{RT} + \lambda_{20}$

FAILURE RATE RT, CONTROL & PREAMPLIFIER

$\lambda_{RA} = \lambda_{RS} + \lambda_{21}$

$\text{MTBF} = \dfrac{1}{\quad} \times 10^{-5}$

SEE TABLE XII FOR FAILURE RATES & MTBF SUMMARY

Figure 61. Radio Set AN/ARC-151(V) (XA-1) Reliability Block Diagram and Mathematical Models

(b) External Forced Air Cooling

The average part temperature for a typical mission is estimated to be 40°C. Average cooling air temperature is 25°C.

(2) Operational Considerations

Each module is assumed to operate at full capacity for each segment of the duty cycle that it is required to provide a function, thus allowances for reduced stress are not considered for those devices or circuits which are biased to cutoff as a result of frequency or mode selection.

(3) Module Independence

The modules are independent, containing independent assemblies, subassemblies, and parts.

(4) Failure Criteria

A system failure is considered to result from a part failure even though the system performance is only slightly degraded or experiences a noncritical reduction in capability.

Parts, such as test points or other isolated bench test related items, whose failure in any mode will have no effect upon the operation of the equipment, are not considered to contribute to the operational failure rate.

(5) Failure Rates

Failure rates are for the grade and class of parts described by their respective procurement specifications when functioning in an airborne environment. The part failure rates are calculated by computer using the equations contained in RADC TR-67-108.

(6) Prediction Results

The results of the analyses are given in Table XII. Each of the constituent modules is listed with its calculated failure rate for the assumed 55°C operating temperature. Additional points are calculated to extend the temperature range. The results of these analyses are shown in Figure 62.

For purposes of illustration, the complete computer printout for the audio processor, module A15 @ 55°C is provided in Table XIII. The balance of the printout for the complete equipment is on file in ECI's Reliability Department and is available for review at ECI on request.

5. CONCLUSIONS

The calculated inherent reliability of the AN/ARC-151(V) (XA-1) UHF Command/Satellite Transceiver is in excess of the specified minimum acceptable MTBF.

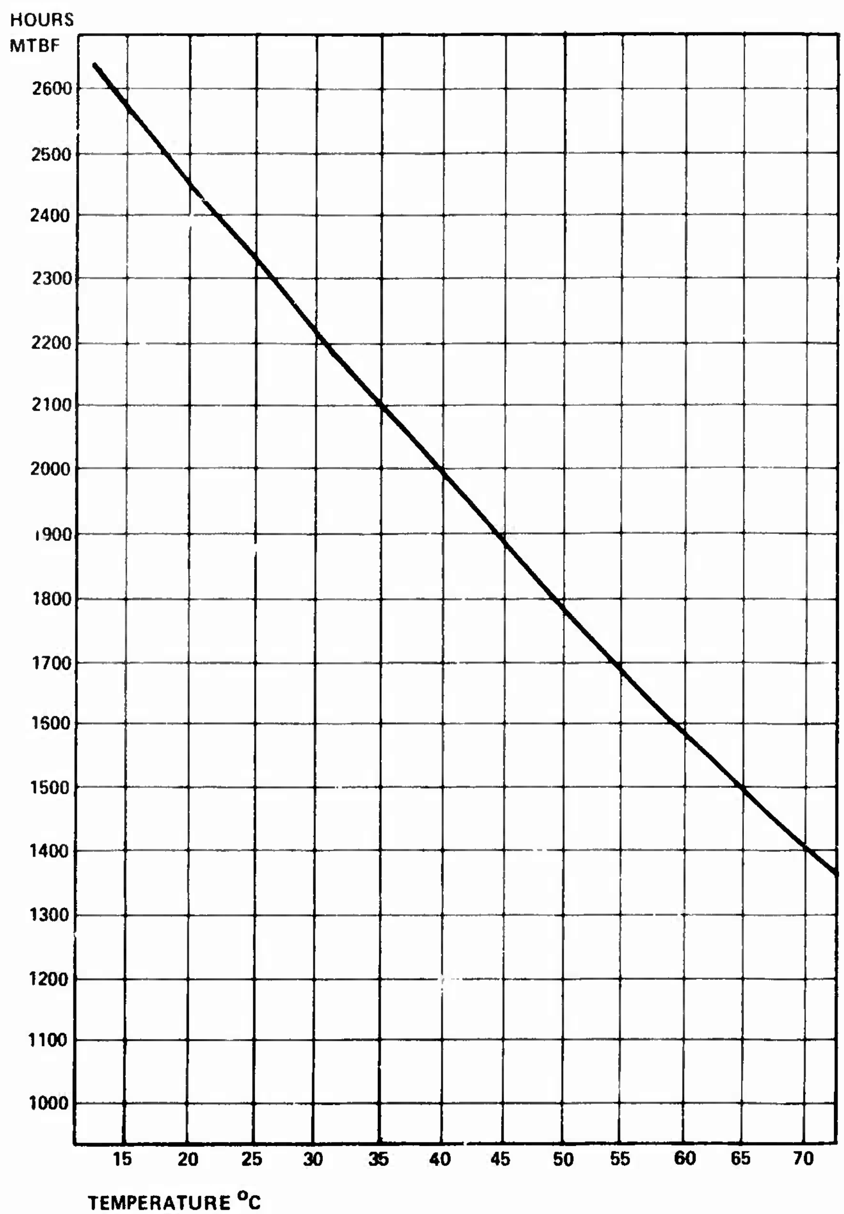


Figure 62. MTBF VS Temperature

Table XIII. Audio Processor Reliability Printout (55°C)

AUDIO PROCESSOR,61-01344-001 (TEMP 55C,ACT PCT DTY CY)

REFERENCE DESIGNATOR	ECI PART NUMBER	PART DESCRIPTION	DUTY CYCLE	RATED TEMP (K)	ACTUAL TEMP (K)	ELECTRICAL STRESS RATED	ELECTRICAL STRESS ACTUAL	STRESS RATIO	DATA SOURCE	APPLICATION FAILURE RATE (FC/1000 HRS)
A15A 0 A1	7200116001	IC,VOLTAGE REGULATOR	1.00	422.5	328.0	0.500	0.050	0.100	1	0.2841261
A15A 0 A2	7200121001	IC, ELECTRONIC SWITCH, DPDT	1.00	423.0	328.0	0.650	0.117	0.180	1	0.0437117
A15A 0 A3	7200148001	IC,OPER AMPL-HI PERFORMANCE	1.00	424.9	328.0	0.500	0.050	0.100	1	0.2130946
A15A 0 A4	7200148001	IC,OPER AMPL-HI PERFORMANCE	1.00	424.9	328.0	0.500	0.050	0.100	1	0.2130946
A15A 0 C1	1100384037	CAPACITOR,FXD CER, CKR	1.00	399.0	328.0	200.000	28.000	0.140	1	0.0009417
A15A 0 C2	1100390015	CAPACITOR, SOLID TANT, CSR13	1.00	398.0	328.0	20.000	10.000	0.500	1	0.0003601
A15A 0 C3	1100384009	CAPACITOR,FXD CER, CKR	1.00	399.0	328.0	200.000	27.000	0.135	1	0.0009347
A15A 0 C4	1100390035	CAPACITOR, SOLID TANT, CSR13	1.00	398.0	328.0	50.000	23.000	0.460	1	0.0003366
A15A 0 C5	1100384021	CAPACITOR,FXD CER, CKR	1.00	399.0	328.0	200.000	28.000	0.140	1	0.0009417
A15A 0 C6	1100384021	CAPACITOR,FXD CER, CKR	1.00	399.0	328.0	200.000	23.000	0.115	1	0.0009112
A15A 0 C7	1100390024	CAPACITOR, SOLID TANT, CSR13	1.00	398.0	328.0	35.000	23.000	0.657	1	0.0004946
A15A 0 C8	1100390054	CAPACITOR, SOLID TANT, CSR13	1.00	398.0	328.0	100.000	5.000	0.050		0.0002543
A15A 0 C9	1100384021	CAPACITOR,FXD CER, CKR	1.00	399.0	328.0	200.000	12.000	0.060	1	0.0008787
A15A 0 C10	1100384013	CAPACITOR,FXD CER, CKR	1.00	399.0	328.0	200.000	12.000	0.060	1	0.0008787
A15A 0 C11	1100384017	CAPACITOR,FXD CER, CKR	1.00	399.0	328.0	200.000	12.000	0.060	1	0.0008787
A15A 0 C12	1100384049	CAPACITOR,FXD CER, CKR	1.00	399.0	328.0	100.000	2.000	0.020	1	0.0008735
A15A 0 C13	1100392001	CAPACITOR,FXD CER MIL-11015	1.00	399.0	328.0	25.000	12.000	0.480	1	0.0036313
A15A 0 C14	1100392001	CAPACITOR,FXD CER MIL-11015	1.00	399.0	328.0	25.000	12.000	0.480	1	0.0036313
A15A 0 C15	1100390015	CAPACITOR, SOLID TANT, CSR13	1.00	398.0	328.0	20.000	8.000	0.400	1	0.0003084
A15A 0 C16	1100392001	CAPACITOR,FXD CER MIL-11015	1.00	399.0	328.0	25.000	2.200	0.087	1	0.0008903
A15A 0 C17	1100384049	CAPACITOR,FXD CER, CKR	1.00	399.0	328.0	100.000	23.000	0.230	1	0.0011767
A15A 0 C18	1100384021	CAPACITOR,FXD CER, CKR	1.00	399.0	328.0	200.000	23.000	0.115	1	0.0009112
A15A 0 C19	1100409008	CAPACITOR,FXD CER MIL-11015	1.00	399.0	328.0	50.000	5.600	0.112	1	0.0009083
A15A 0 C20	1100409008	CAPACITOR,FXD CER MIL-11015	1.00	399.0	328.0	50.000	5.600	0.112	1	0.0009083
A15A 0 C21	1100390009	CAPACITOR, SOLID TANT, CSR13	1.00	398.0	328.0	15.000	12.000	0.800	1	0.0006880
A15A 0 C22	1100390034	CAPACITOR, SOLID TANT, CSR13	1.00	398.0	328.0	50.000	7.000	0.140	1	0.0002565
A15A 0 C23	1100384027	CAPACITOR,FXD CER, CKR	1.00	399.0	328.0	200.000	1.000	0.005	1	0.0008733
A15A 0 C24	1100384027	CAPACITOR,FXD CER, CKR	1.00	399.0	328.0	200.000	1.000	0.005	1	0.0008733
A15A 0 C25	1100384015	CAPACITOR,FXD CER, CKR	1.00	399.0	328.0	200.000	1.000	0.005	1	0.0008733
A15A 0 C26	1100392001	CAPACITOR,FXD CER MIL-11015	1.00	399.0	328.0	25.000	12.000	0.480	1	0.0036313
A15A 0 C27	1100392001	CAPACITOR,FXD CER MIL-11015	1.00	399.0	328.0	25.000	12.000	0.480	1	0.0036313
A15A 0 CR1	2000134004	DIODE,SILICON	1.00	447.7	328.0	0.199	0.001	0.005	1	0.0034742
A15A 0 CR2	2000131023	DIODE,SIL REGULATOR,400MW	1.00	448.0	328.0	0.384	0.004	0.010	1	0.0134634
A15A 0 CR3	2000131020	DIODE,SIL REGULATOR,400MW	1.00	448.0	328.0	0.384	0.003	0.007	1	0.0133860
A15A 0 CR4	2000146036	DIODE,SILICON,REGULATOR	1.00	447.9	328.0	0.319	0.057	0.178	1	0.0183976
A15A 0 CR5	2000134004	DIODE,SILICON	0.00	447.7	328.0	0.199	0.001	0.005	1	0.0000000
A15A 0 CR6	2000134004	DIODE,SILICON	1.00	447.7	328.0	0.199	0.001	0.005	1	0.0034742
A15A 0 CR7	2000134004	DIODE,SILICON	1.00	447.7	328.0	0.199	0.001	0.005	1	0.0034742
A15A 0 CR8	2000134004	DIODE,SILICON	1.00	447.7	328.0	0.199	0.001	0.005	1	0.0069142
A15A 0 CR9	2000134004	DIODE,SILICON	1.00	447.7	328.0	0.199	0.001	0.005	1	0.0069142
A15A 0CR10	2000131026	DIODE,SIL REGULATOR,400MW	1.00	448.0	328.0	0.384	0.010	0.026	1	0.0139383
A15A 0CR11	2000134004	DIODE,SILICON	1.00	447.7	328.0	0.199	0.001	0.005	1	0.0069142
A15A 0CR12	2000134004	DIODE,SILICON	1.00	447.7	328.0	0.199	0.001	0.005	1	0.0069142
A15A 0CR13	2000134004	DIODE,SILICON	1.00	447.7	328.0	0.199	0.001	0.005	1	0.0069142
A15A 0CR14	2000134004	DIODE,SILICON	1.00	447.7	328.0	0.199	0.001	0.005	1	0.0069142
A15A 0CR15	2000146033	DIODE,SILICON,REGULATOR	1.00	447.9	328.0	0.319	0.086	0.268	1	0.0219558
A15A 0CR16	2000146033	DIODE,SILICON,REGULATOR	1.00	447.9	328.0	0.319	0.023	0.071	1	0.0150348
A15A 0 J1	1600852004	JACK,TIP	0.00	424.0	328.0	500.000	7.000	0.014	1	0.0000000
A15A 0 J2	1600852004	JACK,TIP	0.00	424.0	328.0	500.000	1.000	0.002	1	0.0000000
A15A 0 J3	1600852004	JACK,TIP	0.00	424.0	328.0	500.000	3.000	0.006	1	0.0000000
A15A 0 J4	1600852004	JACK,TIP	0.00	424.0	328.0	500.000	23.000	0.046	1	0.0000000
A15A 0 J5	1600852004	JACK,TIP	0.00	424.0	328.0	500.000	11.000	0.022	1	0.0000000
A15A 0 L1	0900415005	INDUCTOR, FXD, RF	1.00	398.0	328.0	0.210	0.052	0.247	1	0.0089999
A15A 0 L2	0900415005	INDUCTOR, FXD, RF	1.00	398.0	328.0	0.210	0.001	0.004	1	0.0089999
A15A 0 L3	0900415005	INDUCTOR, FXD, RF	1.00	398.0	328.0	0.210	0.001	0.004	1	0.0089999
A15A 0 L4	0900415005	INDUCTOR, FXD, RF	1.00	398.0	328.0	0.210	0.001	0.004	1	0.0089999
A15A 0 L5	0900415005	INDUCTOR, FXD, RF	1.00	398.0	328.0	0.210	0.001	0.004	1	0.0089999
A15A 0 L6	0900415005	INDUCTOR, FXD, RF	1.00	398.0	328.0	0.210	0.010	0.047	1	0.0089999
A15A 0 L7	0900415005	INDUCTOR, FXD, RF	1.00	398.0	328.0	0.210	0.072	0.342	1	0.0089999
A15A 0 Q1	2000302008	TRANSISTOR,SILICON PNP	1.00	478.0	328.0	0.500	0.013	0.025	1	0.1274852
A15A 0 Q2	2000232008	TRANSISTOR,SIL PNP	1.00	473.4	328.0	0.331	0.001	0.003	1	0.0121945
A15A 0 Q3	2000195008	TRANSISTOR,SILICON,NPN	1.00	448.1	328.0	0.400	0.001	0.002	1	0.0159539
A15A 0 Q4	2000232008	TRANSISTOR,SIL PNP	1.00	473.4	328.0	0.331	0.001	0.003	1	0.0285837
A15A 0 Q5	2000232008	TRANSISTOR,SIL PNP	1.00	473.4	328.0	0.331	0.001	0.003	1	0.0285837
A15A 0 R1	1000275001	RESISTOR,FXD COMP,1/4W RCR07	1.00	402.9	328.0	0.250	0.010	0.040	1	0.0005996
A15A 0 R2	1000279061	RESISTOR,FXD FILM,1/4W RLR07	1.00	423.0	328.0	0.250	0.014	0.056	1	0.0151078
A15A 0 R3	1000281002	RESISTOR,VARIABLE W/W	1.00	423.0	328.0	0.750	0.003	0.003	1	0.0370593
A15A 0 R4	1000284014	RESISTOR,FXD,W/W,3WATT,RWR89	1.00	548.0	328.0	2.640	1.070	0.405	1	0.0149037
A15A 0 R5	1000281006	RESISTOR,VARIABLE W/W	1.00	423.0	328.0	0.750	0.002	0.002	1	0.0646298
A15A 0 R6	1000279008	RESISTOR,FXD FILM,1/4W RLR07	1.00	423.0	328.0	0.250	0.005	0.020	1	0.0072954
A15A 0 R7	1000279038	RESISTOR,FXD FILM,1/4W RLR07	1.00	423.0	328.0	0.250	0.001	0.004	1	0.0071761
A15A 0 R8	1000279052	RESISTOR,FXD FILM,1/4W RLR07	1.00	423.0	328.0	0.250	0.006	0.024	1	0.0073259
A15A 0 R9	1000279052	RESISTOR,FXD FILM,1/4W RLR07	1.00	423.0	328.0	0.250	0.007	0.028	1	0.0073565
A15A 0 R10	1000279040	RESISTOR,FXD FILM,1/4W RLR07	1.00	423.0	328.0	0.250	0.043	0.172	1	0.0085855
A15A 0 R11	1000279067	RESISTOR,FXD FILM,1/4W RLR07	1.00	423.0	328.0	0.250	0.010	0.040	1	0.0148290

Table XIII. Audio Processor Reliability Printout (55 C) (Concluded)

AUDIO PROCESSOR,61-01344-001 (TEMP 55C,ACT PCT DTY CY)

REFERENCE DESIGNATOR	ECI PART NUMBER	PART DESCRIPTION	DUTY CYCLE	RATED TEMP (K)	ACTUAL TEMP (K)	ELECTRICAL STRESS RATED	ELECTRICAL STRESS ACTUAL	STRESS RATIO	DATA SOURCE	APPLICATION FAILURE RATE (PC/1000 HRS)
A15A 0 R12	1000279084	RESISTOR,FXD FILM,1/4W RLR07	1.00	423.0	328.0	0.250	0.002	0.008	1	0.0142923
A15A 0 R13	1000279046	RESISTOR,FXD FILM,1/4W RLR07	1.00	423.0	328.0	0.250	0.002	0.008	1	0.0072055
A15A 0 R14	1000279046	RESISTOR,FXD FILM,1/4W RLR07	1.00	423.0	328.0	0.250	0.002	0.008	1	0.0072055
A15A 0 R15	1000333122	RESISTOR,FXD FILM RNC50	1.00	448.0	328.0	0.050	0.001	0.020	1	0.0002691
A15A 0 R16	1000333122	RESISTOR,FXD FILM RNC50	1.00	448.0	328.0	0.050	0.001	0.020	1	0.0002691
A15A 0 R17	1000279046	RESISTOR,FXD FILM,1/4W RLR07	1.00	423.0	328.0	0.250	0.002	0.008	1	0.0072055
A15A 0 R18	1000279046	RESISTOR,FXD FILM,1/4W RLR07	1.00	423.0	328.0	0.250	0.002	0.008	1	0.0072055
A15A 0 R19	1000279044	RESISTOR,FXD FILM,1/4W RLR07	1.00	423.0	328.0	0.250	0.105	0.420	1	0.0113523
A15A 0 R20	1000333122	RESISTOR,FXD FILM RNC50	1.00	448.0	328.0	0.050	0.024	0.479	1	0.0004170
A15A 0 R21	1000279037	RESISTOR,FXD FILM,1/4W RLR07	1.00	423.0	328.0	0.250	0.006	0.024	1	0.0073259
A15A 0 R22	1000279067	RESISTOR,FXD FILM,1/4W RLR07	1.00	423.0	328.0	0.250	0.009	0.036	1	0.0147634
A15A 0 R23	1000294007	RESISTOR,VAR CERMET,0.5 WATT	1.00	448.0	328.0	0.500	0.001	0.002	1	0.3656433
A15A 0 R24	1000279070	RESISTOR,FXD FILM,1/4W RLR07	1.00	423.0	328.0	0.250	0.001	0.004	1	0.0142275
A15A 0 R25	1000281006	RESISTOR,VARIABLE W/W	1.00	423.0	328.0	0.750	0.004	0.005	1	0.0597623
A15A 0 R26	1000279009	RESISTOR,FXD FILM,1/4W RLR07	1.00	423.0	328.0	0.250	0.010	0.040	1	0.0074495
A15A 0 R27	1000279046	RESISTOR,FXD FILM,1/4W RLR07	1.00	423.0	328.0	0.250	0.001	0.004	1	0.0071761
A15A 0 R28	1000279054	RESISTOR,FXD FILM,1/4W RLR07	1.00	423.0	328.0	0.250	0.001	0.004	1	0.0142275
A15A 0 R29	1000279052	RESISTOR,FXD FILM,1/4W RLR07	1.00	423.0	328.0	0.250	0.001	0.004	1	0.0071761
A15A 0 R30	1000275008	RESISTOR,FXD COMP,1/4W RCR07	1.00	402.9	328.0	0.250	0.001	0.004	1	0.0006887
A15A 0 R31	1000279084	RESISTOR,FXD FILM,1/4W RLR07	1.00	423.0	328.0	0.250	0.001	0.004	1	0.0142275
A15A 0 R32	1000275008	RESISTOR,FXD COMP,1/4W RCR07	1.00	402.9	328.0	0.250	0.001	0.004	1	0.0006887
A15A 0 R33	1000279039	RESISTOR,FXD FILM,1/4W RLR07	1.00	423.0	328.0	0.250	0.021	0.084	1	0.0078052
A15A 0 R34	1000279050	RESISTOR,FXD FILM,1/4W RLR07	1.00	423.0	328.0	0.250	0.040	0.160	1	0.0084736
A15A 0 R35	1000279046	RESISTOR,FXD FILM,1/4W RLR07	1.00	423.0	328.0	0.250	0.050	0.200	1	0.0088540
A15A 0 R36	1000279044	RESISTOR,FXD FILM,1/4W RLR07	1.00	423.0	328.0	0.250	0.004	0.016	1	0.0072652
A15A 0 R37	1000279052	RESISTOR,FXD FILM,1/4W RLR07	1.00	423.0	328.0	0.250	0.009	0.036	1	0.0074183
A15A 0 R38	1000279052	RESISTOR,FXD FILM,1/4W RLR07	1.00	423.0	328.0	0.250	0.009	0.036	1	0.0074183
A15A 0 R39	1000281002	RESISTOR,VARIABLE W/W	1.00	423.0	328.0	0.750	0.005	0.006	1	0.0376464
A15A 0 R40	1000279061	RESISTOR,FXD FILM,1/4W RLR07	1.00	423.0	328.0	0.250	0.001	0.004	1	0.0142275
A15A 0 R41	1000279061	RESISTOR,FXD FILM,1/4W RLR07	1.00	423.0	328.0	0.250	0.001	0.004	1	0.0142275
A15A 0 R42	1000279056	RESISTOR,FXD FILM,1/4W RLR07	1.00	423.0	328.0	0.250	0.001	0.004	1	0.0142275
A15A 0 R43	1000279058	RESISTOR,FXD FILM,1/4W RLR07	1.00	423.0	328.0	0.250	0.001	0.004	1	0.0142275
A15A 0 R44	1000275008	RESISTOR,FXD COMP,1/4W RCR07	1.00	402.9	328.0	0.250	0.001	0.004	1	0.0006887
A15A 0 R45	1000279058	RESISTOR,FXD FILM,1/4W RLR07	1.00	423.0	328.0	0.250	0.001	0.004	1	0.0142275
A15A 0 R46	1000275008	RESISTOR,FXD COMP,1/4W RCR07	1.00	402.9	328.0	0.250	0.001	0.004	1	0.0006887
A15A 0 R47	1000279038	RESISTOR,FXD FILM,1/4W RLR07	1.00	423.0	328.0	0.250	0.095	0.380	1	0.0108421
A15A 0 R48	1000279026	RESISTOR,FXD FILM,1/4W RLR07	1.00	423.0	328.0	0.250	0.177	0.708	1	0.0159454
A15A 0 R49	1000279022	RESISTOR,FXD FILM,1/4W RLR07	1.00	423.0	328.0	0.250	0.010	0.040	1	0.0074495
A15A 0 R50	1000279075	RESISTOR,FXD FILM,1/4W RLR07	1.00	423.0	328.0	0.250	0.001	0.004	1	0.0142275
A15A 0 R51	1000279075	RESISTOR,FXD FILM,1/4W RLR07	1.00	423.0	328.0	0.250	0.001	0.004	1	0.0142275
A15A 0 R52	1000279052	RESISTOR,FXD FILM,1/4W RLR07	1.00	423.0	328.0	0.250	0.001	0.004		0.0071761
A15A 0 T1	0800763001	TRANSFORMER,AUDIO	1.00	404.0	328.0	50.000	6.000	0.120	1	0.0755999

AUDIO PROCESSOR,61-01344-001 (TEMP 55C,ACT PCT DTY CY)

FAILURE RATE = 2.2864112 MTBF = 43736.679

TOTAL PARTS = 117

Unclassified
Security Classification

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author)
Electronic Communications, Inc.
1501 - 72nd Street North
St. Petersburg, Florida 33733

2a. REPORT SECURITY CLASSIFICATION
Unclassified

2b. GROUP

3. REPORT TITLE
(6) UHF Command/Satellite Transceiver AN/ARC-151.

4. DESCRIPTIVE NOTES (Types of report and inclusive dates)
(7) Final Technical Report, May [redacted]69 [redacted] Sept[redacted]972

5. AUTHORS (First name, middle initial, last name)
(10) J. Bruce Myers,
Harold Z. Snyder
Charles D. Donaldson
(15)

6. REPORT DATE
(11) Dec[redacted]72 (12) 88 p.

7a. TOTAL NO. OF PAGES
[redacted]

7b. NO. OF REFS
1

8a. CONTRACT OR GRANT NO.
(15) F33615-69-C-1818

[redacted] 687J
(16) AF

9a. ORIGINATOR'S REPORT NUMBERS
(14) ECI-1-P-RF-536-0

9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
(18) AFAL-TR-72-324

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11. SUPPLEMENTARY NOTES

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Air Force Systems Command
Wright-Patterson Air Force Base, Ohio

13. ABSTRACT This report describes work on a UHF Command/Satellite Transceiver. The Radio Set is compatible and interchangeable with the AN/ARC-34( ). In addition, the Radio Set is compatible with the space requirements of the AN/ARC-27( ), AN/ARC-51( ), and AN/ARC-109( ). The set provides two-way AM voice, secure voice, FM voice, digital data, ADF, automatic relaying, FSK and satellite communications.

Two Radio Sets were built, tested, and delivered as part of this UHF Command/Satellite Transceiver Program. The two Radio Sets were originally shipped as identically configured AN/ARC-151(V)(XA-1) Radio Sets. Later, a modification to one of the originally shipped Radio Sets was requested which deleted the Link 4 Line-of-Sight FSK Mode and incorporated a TTY 75 bps FSK Satellite Mode. Radio Set AN/ARC-151(V)(XA-1), serial number 00002, was modified, tested, renomenclatured Radio Set AN/ARC-151(V)(XA-2), and delivered as part of this program.

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DD FORM 1 NOV 65 1473
U3 4802 1030 REV 7/66
PART 1 OF 3

Unclassified
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
UHF Command/Satellite Transceiver						
AN/ARC-151						
External 70 MHz Modem						
Ultra Reliable						
100 Watts FM/25 Watts AM						
All Solid State						

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